MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

The Wide Province of the Engineer

Since in the exercise of his functions as an engineer he must of necessity develop and employ habits of mind and methods of study which may be usefully employed in dealing with problems as they arise in all activities of life, therefore should the engineer stand ready to serve, not only in his chosen sphere, but wherever and whenever his habit of mind, his training, and his experience may enable him to contribute a helpful element in this great cooperative enterprise which we call civilization.

W. F. DURAND

(From Presidential Address, A.S.M.E. 1925 Annual Meeting)

JANUARY 1926

THE MONTHLY JOURNAL PUBLISHED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Maybe your welding problem is unique

PERHAPS a new welding method will have to be developed. Possibly the problem will need some engineering thought. It is even conceivable that competent welders will have to be selected and organized into a department.

If you have such a job on hand you will want advice from someone who is more than an expert welder. You can get this kind of help from a Linde Service Supervisor.

Service Supervisors are men of wider experience and broader training than the Service Operators. They act as technical aids to the division sales managers and make their headquarters at the division offices.

NOT LONG AGO a piping contractor had one of those jobs that was going from bad to worse. He was discouraged and ready to quit. Furthermore, the customer was ready to have him quit. A Linde Service Supervisor appeared on the scene. He recommended a better type of welded joint. This was adopted. He suggested training a crew of welders. He outlined a plan for organizing the work; and then he withdrew. The job was finished—completely satisfactory—and ahead of time. We quote from the contractor:—

> "... In these days of so much talk of service and so little except talk, the real service you have rendered to us, to our customer and, incidentally, to the general good of the welding business, is refreshing."

Linde Service Supervisors are a part of Linde Process Service which is free to all Linde users for the asking.

THE LINDE AIR PRODUCTS CO.

General Offices:
Carbon & Carbide Building, 30 E. 42d Street
New York, N. Y.

37 Plants *22 District Sales Offices* *80 Warehouses*

LINDE OXYGEN

YOU CAN DEPEND ON THE LINDE COMPANY

Mechanical Engineering

The Monthly Journal Published by

The American Society of Mechanical Engineers

Publication Office, 207 Church Street, Easton, Pa. Editorial and Advertising Departments at the Headquarters of the Society, 29 West Thirty-ninth Street, New York

Volume 48 January, 1926 Number 1

CONTENTS OF THIS ISSUE

The Engineer and Civilization — *W. F. Durand* — 1
The Vital Need for Greater Financial Support to Pure-Science Research — *Herbert Hoover* — 6
Engineering and Science in the Metal Industry — *Zay Jeffries* — 8
Industrial Coöperation with the War Department — 17
Address of Hon. Dwight F. Davis, Secretary of War — 17
Addresses by Secretary MacNider, and Generals Harbord and Summerall — 20
The German Museum in Munich — *Oskar von Miller* — 21
Normal Pitch the Index of Gear Performance — *G. M. Eaton* — 27
Some Comparative Wear Experiments on Cast-Iron Gear Teeth — *G. H. Marx, L. E. Cutter, and B. M. Green* — 33
The Locomotive Testing Plant — *A. I. Lipetz* — 36
Recent Developments at Colfax Station, Duquesne Light Co — *C. W. E. Clarke* — 39
Higher Steam Pressures in the Industrial Plant — *W. F. Ryan* — 43
Production Control in Newsprint Industry — *G. D. Bearce* — 48
Forty-Sixth Annual Meeting of A.S.M.E. — 67

DEPARTMENTAL

Survey of Engineering Progress — 53
A Review of Attainment in Mechanical Engineering and Related Fields
Engineering and Industrial Standardization — 65
Work of A.S.M.E. Boiler Code Committee — 66
Editorial Notes — 76
The Doctor-Engineer Scans Civilization; The Engineering Museum as a Dynamic Force; Progress in Mechanical Engineering; Better A.S.M.E. Meetings; Industrial Power and Heat; Platform for Engineering Foundation; Appeal for Adequate Salaries for Federal Judges; Constitution of Coal; Unethical Use of Manufacturers' Drawings; Industrial Self-Government; Secretary Hoover's Annual Report; John A. Stevens Appointed Honorary Chairman of A.S.M.E. Boiler Code Committee; Recent Visit of Dr. von Miller Timely and Eventful; President's Aircraft Inquiry; Motorship *Gripsholm;* Statistical.
Book Reviews and Library Notes — 86
The Engineering Index — 89

ADVERTISING

Display Advertisements — 1
Professional Engineering Service Section — 136
Opportunity Advertisements — 141
Classified List of Mechanical Equipment — 143
Alphabetical List of Advertisers — 154

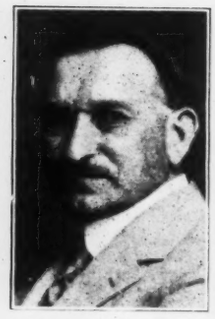
Price 60 Cents a Copy, $5.00 a year: to Members and Affiliates, 50 Cents a Copy, $4.00 a year. Postage to Canada, 75 Cents Additional; to Foreign Countries $1.50 Additional. Changes of address should be sent to the Society Headquarters.

Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921.

G. D. Bearce

W. F. Ryan

B. M. Green



G. H. Marx

L. E. Cutter

G. M. Eaton

Contributors to this Issue

Oskar von Miller, one of the best known engineers in Europe and founder of the German Museum in Munich, first visited this country in 1883 when the first electric-light plant was being installed in Pearl Street, New York City. He obtained from Mr. Edison the rights to install a plant in Germany, which proved a success. He promoted the Frankfort-Lauffen high-tension railway-electrification of experiments in 1890 and was also a pioneer in the field of hydroelectric experimentation. At the zenith of his career he took up the project of establishing an industrial museum which has proven a model for similar museums throughout the world.

* * * * *

G. M. Eaton is chief mechanical engineer of the Westinghouse Electric & Manufacturing Co. He was graduated from Worcester Polytechnic Institute in 1894. From then until 1906, with the exception of two years spent with the Union Iron Works of San Francisco (1898–1900), he was connected with the Newport News Shipbuilding and Dry Dock Co. Since 1906 he has been with the Westinghouse Co.

* * * * *

Guido H. Marx is professor of machine design at Stanford University. He was graduated from Cornell in 1893, with a degree in mechanical engineering. Prior to entering Cornell he worked for the Sill Stove Works, of Rochester, N. Y., and subsequent to his graduation he was with the Gleason Works, of Rochester, and Bement, Miles & Company, of Philadelphia. He has been on the teaching staff of Stanford University since 1895.

* * * * *

Lawrence E. Cutter is associate professor of mechanical engineering at Stanford University. He served his apprenticeship as machinist with the Union Iron Works, San Francisco, Cal., and worked for this company as a machinist, and later as a draftsman, before entering Stanford University as a student. He was graduated from Stanford in 1906, in the department of mechanical engineering, since which time he has been a member of the faculty.

* * * * *

Boynton M. Green is assistant professor of mechanical engineering at Stanford University. He was graduated from that school in 1914, and received his M.E. degree from the same institution in 1916. His engineer's thesis on bearing lubrication received one of the two student prizes awarded by the Society in December, 1916. After graduation he joined the H. Koppers Company, of Pittsburgh, Pa. Later he was with the Federal Telegraph Company, of San Francisco. Since 1921 he has been teaching at Stanford University.

* * * * *

A. I. Lipetz is consulting engineer with the American Locomotive Co., Schenectady, N. Y. He attended both the Polytechnic Institutes at Warsaw and Kiev, of which latter he was formerly assistant professor. For four years he was chief of the Tashkent Railroad, Russia. Later he held the positions of chief of the locomotive department of the Russian Mission of Ways of Communications, and assistant professor of the Institute of Engineers of Ways of Communication, Petrograd. In 1916 he was sent to the United States as representative of the Railway Administration in Petrograd.

* * * * *

C. W. E. Clarke is consulting engineer with Dwight P. Robinson & Co., New York, N. Y. His early associations were in Chicago, where he designed several power and refrigerating plants for Armour & Co. Later, as chief draftsman for Sargent & Lundy, design specifications aggregating 100,000 kw. in the Chicago district were conducted under his direction. In 1907 he became associated with the New York Central Lines, and was in charge of mechanical engineering in the New York electrical zone until 1910. From that time until 1918, when he joined the Dwight P. Robinson & Co., Mr. Clarke was connected with the firm of Stone & Webster, Boston, Mass.

* * * * *

William F. Ryan, power engineer for The Solvay Process Company, Syracuse, N. Y., was graduated from Harvard College in 1911 and from the Harvard Engineering School in 1913. From 1913 to 1917 he was employed by the Interborough Rapid Transit Co., of New York City, first as assistant engineer on construction, then in the steam operating department, and later as construction superintendent on the installation of three 30,000-kw. turbine generators at the 59th Street Power Station. From 1917 to 1919 Mr. Ryan was chief power-plant engineer for the Wright-Martin Aircraft Corporation, at New Brunswick, N. J., and then entered the employ of the Harry M. Hope Engineering Co., of Boston, Mass.

* * * * *

George D. Bearce, associated with the News Print Service Bureau, is a graduate of the University of Maine. He has been connected with the paper industry for the past twelve years, his early work being with the Great Northern Paper Co., on woods surveying and timber estimating. His actual paper-mill operating experience was received with the Odell Manufacturing Co., now the Groveton Paper Co., following which he spent about one year with the International Paper Co. Mr. Bearce also was connected with the Mead Pulp and Paper Co. for several years. He is chairman of the committee on Waste in Industry of the Technical Association of the paper industry.

Special Features in this Issue

In this issue are published the first of the Henry Robinson Towne and Robert Henry Thurston lectures, delivered respectively by Hon. Herbert Hoover, Secretary of Commerce, and Dr. Zay Jeffries, the eminent metallurgist, before The American Society of Mechanical Engineers at its 1925 Annual Meeting, held in New York the first week of December.

There also appears an account of the Session on National Defense, at which Hon. Elbert H. Gary presided and Secretaries of War Davis and MacNider and Generals Harbord and Summerall spoke; and the address of the Society's retiring president, Dr. W. F. Durand.

MECHANICAL ENGINEERING

Volume 48 January, 1926 No. 1

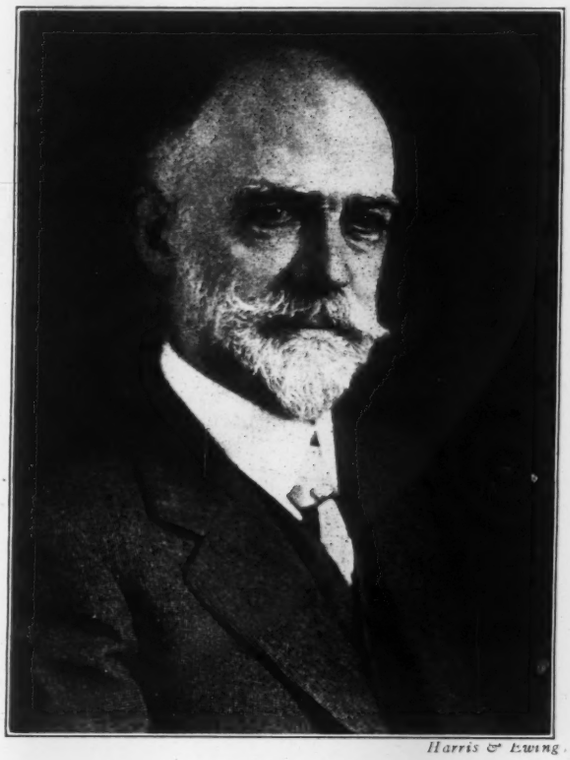
The Engineer and Civilization[1]

By W. F. DURAND, STANFORD UNIVERSITY, CAL.

IF WE MAY ACCEPT the estimates of archaeologists, it is now some hundred thousand years or more since man began to manifest, in some marked degree, those characteristics which have served as the foundation upon which the superstructure called civilization has been erected.

Throughout this long evolution, three great principles or lines of action have stood out as the determining factors. These are, specialization, coöperation, and the utilization of the resources of nature. These are, in fact, all interrelated. No one is independent of the other two.

So long as the unit of life is the individual, or at most the family, there can be but small progress toward a state of what we term "civilization." So long as a man or a family must do all the things necessary for his or its life, no one thing can be done with super skill or super excellence, and progress must needs be slow. The acquirement of super skill or of super excellence means specialization, concentration, and the limitation of activity to a relatively narrow line of endeavor. Only by this pathway can progress be made. But if the individual is to limit his own activity to a narrow line of endeavor and give to this field of work his entire time and effort, he will obviously be in no position to provide for himself, at first hand, more than some few of the things needful for life, and he must perforce depend on others for those things which he cannot supply himself. This means that he must contribute from the results of his own skill to the needs of his neighbors, and that he must count on receiving from them, in return, the products of their special skill to supplement his own lack. Thus is born the principle of coöperative effort, and out of this flows, of necessity, the commercial institution of barter and exchange.



Harris & Ewing

W. F. DURAND

The Beginnings of Material Civilization

If we seek to place a finger upon the very beginnings of what we may term "material civilization," we shall find it at that point where some race or community of men of primordial stamp and character began to realize and enjoy the advantages accruing through the utilization of some combination product of human skill directed upon a raw material of the earth. For, with the growth of such a condition, there would come a premium on human skill, and thence an inducement for specialization and concentration on some particular line of human endeavor. And with this must come the whole train of specialized human effort, coöperation, and mutual dependence as foundation blocks for the building up of a civilization.

Again, if we seek to place a finger upon the time, place, and circumstance when, where, and how such a condition first came into evidence as a guiding factor in human evolution, we shall apparently find at least one such point in central and southern Europe during the old stone age, and in connection with the utilization of flint arrow and spear heads for the chase, and of other crude stone implements for the simple and homely arts of that far-away time. Man had placed his foot on one of the first rungs of the ladder of progress toward civilization when he found a way of adapting the crude stone fragments lying about him to the needs of life. Definite and material advantages accrued as a result of the use of such implements fashioned from these resources of nature—certainly among the first of such resources to be utilized for other than direct food purposes.

To take, for a moment, a more narrow view in point of time, consider the culmination of this age in the so-called Solutrian phase of culture, and located, in time, perhaps twenty-five thousand years ago.

In that age there might have been seen, about the wonderful limestone caves of southern France, communities of the people of the age, living in or about the caves and practicing the arts of the time. The food supply came primarily from the chase and the flint arrow head and spear head played here a most important part. In this age the art of fashioning flint arrow and spear heads seems to have reached its culmination. In no age before or since have there been produced their equals in beauty and perfection of form, proportion, and finish.

Now there seems to be good evidence that the peculiar skill which was required to shape these beautiful examples of chipped-stone art was by no means the common property of all the men of a community. Rather was it, presumably, the property of a limited few, or perhaps of one, who would thus, by force of circumstance, become the arrow- and spear-head maker for the community. Here then perhaps may we discern the very *first* example, in the development of our civilization, of a clearly defined specialization or differentiation of function in a community of human beings. And with such specialization there must come coöperative relations, barter, and exchange, and thus the foundation for a modern state of society.

Is it too forced a use of language to call this ancient arrow-head maker an industrialist, perhaps an inventor, and an engineer?

It is of the essence of the work of the industrialist that he shall organize, plan, and carry forward undertakings calculated to provide, often in quantity and through repetition processes, the material things of which civilization has need.

It is of the essence of the work of the inventor that he is able to recognize some need in the arts of civilization and to find a way to supply such lack.

[1] Presidential Address at the Annual Meeting, New York, November 30 to December 4, 1925, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

It is of the essence of the work of the engineer that he deals in a large way with the constructive materials of the earth and with the energies of nature—all to the end of useful service in the arts of civilization.

The Arrow-Head Maker the Prototype of the Industrialist and Engineer

Surely we can discern in the work of this ancient arrow-head maker and in his relation to the community life of that day the clear beginnings of those functions which, in more recent times, we designate as those of the industrialist, the inventor, and the engineer. Indeed, the distinction between these terms is often arbitrary, and the same individual may be, and often is, any one, two, or all three of these at one and the same time. If, then, we may designate, in a large way, this field as that of the engineer, we may fairly say that far back in those prehistoric times, easily 20,000 to 30,000 years before we have even the beginnings of recorded history, we may clearly discern the germ and the essence of the exercise of that function in society which we, as engineers of a later day, consider our own peculiar responsibility.

But the arrow-head maker of the old stone age by no means stands alone as a prototype of the modern engineer. There is his fellow, perhaps of a somewhat later time, who invented the art of weaving, especially as expressed in crude basketry, and thus gave to man, perhaps, his first container or carrier. And again, not long subsequent, that ceramic engineer who discerned, perhaps first through the burning of a clay-lined wickerwork basket, the influence of fire upon clay, and thus laid the foundation of the great modern ceramic industries which have come to mean so much in our own day, and the development of which can be so clearly traced down through the ages. And again, what of that engineer-scientist-inventor of 20,000 years ago, perhaps, who gave to the world of that day the bow and arrow with its wonderfully effective utilization of the laws of mechanics regarding the transformations of energy? We may, in fact, see in play here the entire sequence of invention and engineering science.

Primitive Utilization of Mechanical Laws

All invention must start with the recognition of a lack or need, and following this there must be some mental vision of a manner in which this lack or need may be supplied. The invention must be subjective before it can become objective. There must be in the mind of the inventor some mental picture of the means whereby the lack may be filled before it can become clothed in material form. And so some one, in some way, in those remote times caught some realization of a need or insufficiency in the weapons used in the chase, and following upon such recognition he must have gained some mental picture of a way in which the need could be met and the insufficiency supplied. And so was produced the combination of bow and arrow, with its wonderfully effective means for receiving the organic energy of the bowman as he pulls the arrow and flexes the bow, and for storing it in potential form, expressed as the potential energy of a distorted elastic system. And then, at the instant of his choice, with the arrow released by the fingers, this stored energy becomes transformed into kinetic energy expressed in the flight of the arrow toward its mark. Truly a wonderful series of energy transformations, and realized with marvelous efficiency and perfect adaptation to purpose!

The Great Antiquity of the Engineering Profession

Do we, as engineers of the present day, stop to remember that whenever, in our modern mechanism, we utilize a spring, no matter of what form or character, we are simply following along the path marked out by this great inventor-engineer of the long ago? Do we not, as did he, simply use the distortion of an elastic system and its release as a means for storing and transforming energy? And again, in this same category of scientist-engineer, there is the inventor of the sling. This ancient military engineer or huntsman found a way of utilizing the kinetic energy of a rapidly rotating material system. We do the same with the flywheel, and, so far as basic principle is concerned, we are simply again following along the pathwav first worked out by this engineer-inventor of a vanished race and of a departed age.

And again, have there not been naval architects and shipbuilders since the days of the long dugout—a period of not less than 15,000 years? Have there not been bridge builders since our ancient forebears—no one can guess how many ages ago—first learned to throw a log across a stream, or to stretch, suspension-wise, cables made of twisted vines or other like material?

And have there not been metallurgists and metallurgical engineers since the days of Tubal Cain, who, as we are told in Genesis, was "an instructor of every artificer in brass and iron?" And have there not been great structural engineers and builders who for 6000 years past at least have been enriching the earth with the products of their genius and skill—as witness the wonders of Nineveh, Babylon, Egypt, Greece, and Rome, or again the records of the Maya and earlier civilizations on our own continent?

And so, as we follow the sequence of the utilization of the constructive materials of Nature and of her energies, down through the ages—from the products of early paleolithic or rough chipped-stone culture to later paleolithic, and then to neolithic or polished stone, horn and bone, and then on to bronze and so finally to iron and steel and thence into the more complex conditions of modern times—we see continuously and clearly the accumulating results of specialization, of coöperative human labor, and of the inheritance, by each successive generation, of the accumulated culture of those which have preceded it.

If I have taken this length of time to examine the early beginnings of the art and practice of engineering, it has been to draw attention to the great antiquity of our profession and to justify, in some degree, the claim, which we may make, of belonging to the first group or guild of society which became distinguished in relation to the community at large by reason of some peculiar or special function or service rendered.

We sometimes consider that engineering and the engineer, in the distinctively modern sense of the terms, do not antedate the invention of the steam engine and the beginning of the utilization of the inorganic energies of nature—those developments which have so revolutionized the material content of our civilization during the past 200 years. The distinction, however, is superficial rather than fundamental; the informing spirit and purpose are the same. The difference results primarily from the enormously increased magnitude and diversity of the material content of our present-day civilization, arising from the utilization of the inorganic energies of nature in lieu of the organic energies of man or domestic animals. It has resulted, naturally, that the engineer of today must be a man of far different training and type of activity than his brother of 300 or 500 or 1000 or 10,000 years ago. But the point which I make is simply that in spirit, in purpose, and in relation to the civilization of the age, the art and practice of the engineer of the present day have their roots far back before the dawn of written history—back in those first movements in human society which gave evidence of the working of some leaven of evolution, and which in 100,000 years or more have led us from the condition of our paleolithic ancestors up and into the condition and circumstance which we now enjoy.

Modern Material Civilization a Product of the Engineering Guild

And so, in these latter days, we have come into a state of civilization, so called, of which the objective content, with its richness and complexity, is the product of this guild of those who work with the materials of the earth and with the energies of nature. But so commonplace has all this become that the world accepts us and we accept ourselves as part of the scheme of things with little thought of the extent to which this work of the engineer, in the broadest sense of the term, permeates our entire community life.

Suppose we take so humble an object as the slice of toast which appears on our breakfast table. Do we stop to consider the extent to which engineering and the engineer have entered into the vast coöperative enterprise necessary to the production of so commonplace a result? Thus we find that the soil on which was grown the wheat was turned up by a gang plow drawn by a tractor. The grain was sown, harvested, winnowed, and bagged by machinery driven by power. The bags of grain were transported to a rail shippping point by motor truck and thence by rail to a wheat center. The entire program of milling, transport of flour to bakery,

mixing, kneading, baking, and delivery at the kitchen door is again realized through the use of power and energy. And finally, its preparation on the electric toaster is an expression of the utilization of power in its very latest and most versatile form.

And again, what of the design and construction of all these mechanisms and agencies—the plow, the reaper, the motor truck, the locomotive and the freight car; the rails on which they run, the bridges, trestles, and tunnels over and through which they pass; the flouring mill, the bakery equipment, the auto-delivery wagon, and finally, the long line of electric machinery, apparatus, and equipment which takes mechanical energy at a far-distant point transmutes it into the electrical form, and brings it over mountain and valley and across plain to our door, and so to the electric toaster on the breakfast table; there again to be transformed into heat and applied to the bread to render it the more toothsome? And as we thus eat our toast while reading the morning paper, what thought do we give to the manifold energy transformations, the hundreds of mechanisms, devices, and appliances and the thousands of individuals whose joint labor and service have made this simple act on our part possible?

Or again, consider the newspaper itself. The happenings of the entire world are brought by telegraph, telephone, radio, or mail service, assembled within one room, there by typewriter transformed into copy, thence, by the aid of wonderful type-forming machines and technical processes, expressed in the form of records on cylindrical metal shells, and thence, through one of the marvels of modern inventions the printing press, transformed into the printed page, moved by auto truck, railway train, and otherwise, and finally laid on our doorstep ready for consumption with the toast. All of these complex operations and processes, as well as the mechanisms and agencies through which they are realized, are again only an outward expression of a combination of the materials of the earth, the energies of nature, and the directive agency of man, and therefore fall within the direct and peculiar field of the engineer.

And as with these familar examples, so with the entire *material* content of our civilization. The food we eat, the houses in which we dwell, the clothes we wear, the facilities we enjoy by way of travel—on land, over water, or through the air, of trade and commerce with the farthest ends of the earth, of communication with our fellow by written word, telegraph, telephone, or radio, the *material* facilities and means through which we maintain an ordered state of society through government and judicial procedure, the *material* means whereby we transmit the culture of our own age to our children through education, and indeed the *material* background of the organization of our society which makes it possible for select spirits to find time for reflection, for study, for things of the mind and of the spirit rather than things of the body—turn which way we may in the tangled maze of our modern life, and we find on every hand dependence, in some degree at least, on that combination of constructive materials, energies of nature, and the directive agency of man which constitutes the especial field of activity and service of the engineer.

This enunciation of the place of the engineer in the progress of civilization is uttered in no boastful spirit and with no purpose of exalting his services over those of his brothers in arms. The carrying on of our present-day civilization calls for the exercise of a vast number of diverse though interdependent functions. There is no need of an attempt at enumeration. All are necessary, and no one is independent of the others. Rather all are dependent on each and each is dependent on all. If the tiller of the soil, the herdsman, the merchant, the banker, the doctor, the lawyer, are all dependent on the engineer, so is he in turn dependent on them. Life is like some intricately woven web of chain mail wherein each link is necessary to, and in turn dependent upon, all the others. Truly, the ideal of our civilization is that one shall labor for all and all for one.

And so, in the endeavor to mark out the place of the engineer in our modern civilization the purpose has been not to exalt but rather to bring into emphasis the opportunity for service as the measure of the responsibility which attaches to us, both in our individual and collective capacities.

If we, as a guild, stand as the repository of the results of the work of our fellows in bygone ages, even from prehistoric days down to the present time, and as trustees for its useful application to the requirements of our own times, then must we, as a guild, recognize our responsibilities to worthily carry on with this great accumulation which has been placed in our hands. It is only the simple truth to say that the trend of civilization in coming ages—especially as to its material content—will depend in fundamental degree upon the manner in which we discharge our obligations during the short day in which this responsibility and opportunity are placed in our hands. We pass this way but once; the opportunity will not come again. Future ages and future generations are waiting the enjoyment of a *material* civilization, the character of which is, in some measure at least, in our hands to determine, here and today.

How the Engineer May Best Serve the Cause of Advancing Civilization

If now we turn to more practical aspects of the matter and ask how we may so act as to properly discharge these duties and responsibilities, we come fairly face to face with the simple query: What is the duty of the engineer of today, and how may he best serve the cause of advancing civilization?

The discharge of a duty is, in large degree, a personal matter; we cannot easily lay down directions for the individual, but, in the aggregate, we can perhaps safely venture to indicate what seems to be the line of obligation.

In the first place, it is perfectly clear that each individual owes it as a duty to himself, to his guild, and to the world at large that he cultivate to the highest practicable degree the faculties and gifts of which by heredity and environment he has become the living expression.

This is simply an application of the parable of the talents, and there is no reason for argument or discussion. Its application and the resultant obligation upon the individual are self-evident.

But individual bricks do not make a building, nor isolated human units a society. If there is any one lesson to be drawn from a study of the evolution of our civilization, it is that of the significance of coöperation. This is the mortar which serves to bind together the individual units and make of them a coherent, enduring, and purposeful structure.

And so, binding together the individual units of our society, there must be the spirit of coöperation; and if this is true for society at large, it is doubly so for those of the guild of the engineer. No one is better qualified to realize the basic law of mechanics that mass effect can be realized only by mass action. The time has gone by when man might be measurably sufficient unto himself. This is the age of great undertakings, and these can be realized only through joint and coöperative effort.

The Part Engineering Societies Have Played in the Developments Signalizing the Last Half-Century

And so, in order to further such ends we as engineers have organized ourselves into groups with closely allied interests and purposes, and have thus formed the great engineering societies of the present day.

If we form, as best we may, in mental vision some composite picture of these great organizations the world over, we shall obtain a most impressive realization of the application of this principle of coöperation and mutual helpfulness. And no one who will study this picture will fail to realize the significant part which these societies have played in the great engineering developments which have signalized the last half-century. It is not perhaps too much to say that the organization of these societies, furnishing as they have great centers around which engineering activities have crystallized, has constituted the most important single element in making possible these latter-day achievements in engineering; and that during this time they have played a vitally essential part in this march along the lines of material progress.

And here again, what has been said with regard to the development of the individual will furnish a sure guide when applied to these great organizations as groups of individuals.

The engineering societies, collectively and individually, will best serve the public welfare and best contribute to the progress of civilization by developing, each in its own sphere, to the highest possible degree. The picture of one great engineering society

embracing all who may call themselves engineers and covering the whole field of engineering activity and service, is indeed a beautiful ideal. It seems hardly practicable, however, having in view the great diversity of interest and character of work, and the limitations of the individual regarding the extent of the field which he himself can cover. Were indeed any such society organized, it would inevitably divide up into sub-groups, divisions, sections, and what not, each one corresponding to some one measurably narrow field of interest and activity, even as we note similar centrifugal tendencies in the older and more widely comprehensive societies of the present day. And so we may conclude that intensive development, each within its own boundaries, and assiduous cultivation, each of its own field of activity, will best contribute to swell the grand total of service which the world expects of these great organizations, and which they are under obligation to render.

But the parallel between the individual and the society must not stop here. If coöperation is necessary between and among individuals in order to achieve larger ends, so also is it necessary between and among societies in order that *they* may achieve the larger ends which the progress of civilization demands. There are many problems of wide sweep for the solution of which the world is looking to the engineer—or to the engineer in alliance with his brother the scientist—and which touch simultaneously the fields of activity of several of our modern engineering societies. These cannot be adequately and properly studied by any one body or group alone. All the mental acumen which can be brought to bear upon these problems will be none too much to light up the pathway toward some solution. Again, the lines of demarcation between the fields of activity of our several societies are often vague, and many fields of activity may fairly enough be claimed by more than one of them. All of this is of course well known, and is a natural result of the marvelous growth in the activity of the engineer during the past half-century and the vast extension in the scope of his work. This situation, however, should lead only to the exhibition of a spirit of kindly coöperation and friendly emulation, motivated throughout by a readiness to unite wholeheartedly in joint undertakings, whenever or wherever such procedure may indicate a more useful result than through individual society effort.

Some Questions for Engineers in Their Individual and Collective Capacities

Let us attempt to gather up in a single sweep of vision some concept of the great guild of the engineer with its historic background, tracing far away to the very first impulses toward civilization and with its unique and important place in the fabric of our present-day life; and with this concept in mental vision, will it be amiss if we ask ourselves a few questions?

Do we, either as individuals or as societies, often enough seek out the mountain tops and endeavor, from such vantage point of view, to place ourselves in relation to the great problems and movements of the day and to properly orient our own purposes and aims in relation thereto?

Are we, both as individuals and as societies, too prone to the microsocopic view rather than the telescopic?

Are we so occupied with the immediate task, with that which is set before us as the day's work, that we are in danger of failing to appreciate the articulation of our own task with that of our fellow, or to give thought as to how his task and ours may best fit in to the great problems which the progress of our civilization presents?

Have we, either as individuals or as societies, sufficiently well-defined goals or purposes in our professional life? Have we definite aims professionally toward which we are working with a conscious purpose, or are we following too much the opportunist policy of dealing as best we may with individual problems as they arise, and of doing the day's work as it comes along?

Again, are we, either as individuals or as societies, sufficiently alive to the opportunity and duty of taking constructive and helpful part in the larger life movements about us? Do we sufficiently realize the obligation which lies upon us of contributing, as opportunity may offer, helpfully to the solution of great problems which may seem to lie aside from the normal field of our professional life?

Do we, in short, sufficiently realize the obligation of good citizenship along and parallel with the day's work in our chosen field of activity?

Are we, in brief, both as individuals and as societies, striving to definitely direct our course over the sea of life with a firm hand at the helm, with definite objectives in view, with a long look ahead, with a generous recognition of our duty to the generations coming after, and with an appreciation of the larger duties of life as members of a great social organism? Or, are we looking only at our immediate environment with its professional problems, and allowing ourselves, with reference to the larger aspects of life, to drift, subject to currents and tides of which we take little or no heed?

These are indeed searching questions. You of the profession are as well able to answer them as am I. But it will perhaps be safe to assume that neither as individuals nor as societies is our score in these respects what it should be.

If then we imagine ourselves upon the mountain top, may we spend a few moments in looking a little more closely at some few of the things which we might thus discern, and, seeing, ask ourselves whether or not we are living up to the full measure of our obligations thereto.

The Duty of the Engineer as Regards Conservation of Natural Resources

Among the many which might thus challenge our attention, none is perhaps of greater importance than that aspect of the duty of the engineer which centers around the general term "conservation of natural resources."

We have already noted the peculiar position in which the engineer stands relative to the constructive materials of the earth and to the inorganic energies of Nature. He is their custodian, and charged with the duty and has assumed the responsibility of their development and use to meet the requirements of human progress.

Now the facts are, as engineers well know, that the supplies under these categories are far from unlimited in extent. We know of this fact of limitation and that in some instances it is defined with relative sharpness. Furthermore we have no assurance of the operation of natural agencies tending toward replacement, at least in any degree commensurate with the rate at which we are carrying on with their exploitation and exhaustion. Future generations may perhaps grow beyond the need of some of the things which we now find necessary. Substitutes may be found in some cases. But we cannot be sure of this, and in the absence of such assurance it does devolve upon the engineer as a most weighty obligation that he give heed to the means which he employs in the exploitation of these natural resources, and that every possible effort be made to avoid waste and to use them with the highest attainable degree of economy and efficiency. Avoidable waste is a direct theft from generations to be. With the lack of care which has characterized much of the exploitation of the resources of Nature, especially during the last half-century, have we not wasted, in some measure, the patrimony of our children and grandchildren? Imagine that in some way the progress of civilization had been hastened and that the exploitation of the resources of Nature had begun on a grand scale with the Romans, two thousand years ago; and suppose that they and their descendants had carried on, as have we during the last fifty or one hundred years; in what condition should we be today? We are not to infer that the sole responsibility in these matters lies with the engineer—he may fairly share it with society as a whole; but after all, his is perhaps the major share because no one is so well qualified as he to see the consequences of the reckless exploitation of Nature, and upon no one does the duty lie so clearly to lift up his voice in protest and to direct his professional energies and skill along lines looking toward the reduction of waste and inefficiency to the lowest minimum.

To this latter duty he has, in fact, responded, and in many cases with most gratifying results. But the end is not yet, and only by untiring, wholehearted, continuing effort along such lines can the engineer in anticipation look fearlessly in the eye his brothers of the next generation, or the next century, and await their estimate of the manner in which he has discharged the duties of his own day and generation.

Again, if from our fancied mountain top we look in another direction, we shall see ourselves as legatees of a hundred thousand years and more of a gradually growing accumulation. Each age and generation has added some quotum to this vast accumulation of which we are the trustees and executives. Can we either as individuals or societies take a just sense of pride in what we are accomplishing from year to year in this respect? And coming closer home, are we as a society discharging our whole duty in the matter of research and its support? With our numbers and our resources, should we not take a more aggressive stand in this matter and devote, year by year, a larger share of our energies and of our resources to the support of research along lines which lie within the field which we consider peculiarly our own?

The Renewal of Personnel in the Engineering Profession through Technical Education

But let us turn again and note another aspect of our place in the present fabric of civilization. Our guild is like a great army, constantly in need of new recruits in the ranks of the younger strata as its numbers become depleted by age and casualty in those of the older. This is, in short, the great problem of the renewal of personnel, and translates itself into the problem of education for those who are planning to enter our ranks.

It will probably not be claimed that either as individuals or as societies have we in general shown the degree of interest in this subject of engineering education which its importance requires. The technical schools and colleges are intended to furnish opportunity for the effective training of those of our youth who are to furnish at least a very considerable quota of the new recruits in our ranks. Other things equal, we are more likely to find the leaders of future years among those who have been so trained. Of what vital importance it is, then, that we should coöperate with those whose duty it is to direct these great educational activities, to the end, on the one hand, that their measures may be taken with full knowledge of the ever-changing requirements on the firing line of the profession, and on the other, that those who are to receive these new recruits and direct them into the active work of their calling may do so with a sympathetic knowledge of the scope, character, and necessary limitations of training which can be given in the course of a technical curriculum.

As one with some years of experience as a teacher, I am only too ready to admit the inadequacy, in some respects, of the training which our engineering and technical schools are now giving, due in large degree, I believe, to the lack of sufficient contact between the schools and the fields of activity in which their output, as an educational product, is expected to take its place. On the other hand, I believe that some, at least, of the criticism which has been directed toward the product of our technical schools and colleges has arisen as a result of asking or expecting the wrong things of the neophyte—as a result of a lack of understanding or appreciation of the limitations with which the new recruit must approach his job. These conditions can certainly be vastly ameliorated by a better understanding on both sides. The schools and colleges are certainly desirous of such a better understanding, and to us, as societies, the duty now comes, with a significance and an importance which it would be hard to exaggerate, to arouse ourselves to a more active interest in this subject of the training of the recruits for our guild, and to insure that, as far as may be humanly possible, this training shall be such as to best give a well-rounded development of the mental faculties, stimulate genius—if there be such a spark—and withal awaken and foster those characteristics which will make for accurate thinking, independence, originality, devotion to truth, leadership, and high character.

As we know, a splendid beginning has been made toward this closer approximation of the educator and the requirements of the field of active practice, by way of the survey which is now being carried on through the agency of the Society for the Promotion of Engineering Education.

This is a subject of vital importance to the future of our engineering societies and to the whole future trend of progress along engineering lines. It should receive unqualified and wholehearted support from these societies, and nothing less will clear us of the obligation which we are under to prepare, as best we may, for the next generation of leadership in our guild.

The Engineering Method and Its Application to Public Questions

The duties and obligations to which I have directed your attention thus far have lain in close relationship to our work as engineers. But there are wider duties and obligations. We are engineers and as such hold a position of peculiar trust and responsibility in connection with the progress of civilization. But we cannot live unto our guild alone. We are citizens of a complex civilization and touch on every hand problems of life and destiny in which we must take some part.

In a sense, life is a complex of problems. The interrogation point presents itself to us on every hand, and in regard to every relation in life.

But the solving of problems in his own field is, in a peculiar sense, the meat and drink of the engineer. His professional work is, in very large part, concerned with just this form of activity, and he has developed and used, consciously or unconsciously, a form of grand strategy which he has found absolutely essential for the effective study of these situations in life.

Thus he knows that a problem presents in general a complex of factors, and that as the first step such factors must be recognized and listed; and furthermore that such a census must be exhaustive—that no factor must be omitted. Again, he knows that such factors must be evaluated in one form or another, that their interactions must be studied—all with a view to their relations to the particular character of the conclusion which it is desired to draw.

And then with all this material in hand it must be subjected to some logical process—formal or informal—and a conclusion drawn. Often, in fact as a rule, the material resulting from the census and evaluation of factors is of necessity incomplete. In many cases the logical process must be informal rather than formal. In all such cases judgment must supply the missing elements if a solution is to be reached. However, no one knows better than the engineer the need of discrimination between the sure ground of known data and formal logic, on the one hand—as exemplified, say, by mathematical operations—and acts of judgment on the other; and no one has learned through wider experience than the engineer the need of applying his conclusions in the light of that component part which, of necessity, has been dependent on estimate and judgment.

But if such, in broad outline, are the characteristics of the grand strategy which the engineer is accustomed to apply in the study of problems in his own field, how or where could we find a better mode of approach for the study of all problems in life, whether of economics, diplomacy, international affairs, problems of the nation, of the state, of the municipality, of the school district, of trade and commerce, of finance, of education—in a word, of all relations in life which go to make up the complex of our modern civilization?

This does not mean of course that the engineer as such can pose as an expert in the study of problems in these varied fields remote from his own normal activity. It does mean that his own general grand strategy is equally applicable in such fields as in his own, and therefore to that extent is he qualified to serve effectively with others who may be able to supply the more narrowly technical details, in the study of a wide variety of problems in life and lying outside his own special field. It means, in particular, when such problems involve questions of engineering or when they have an engineering background, as is so frequently the case, that he is especially well qualified to take an important and helpful part in the broad and thorough study of such matters, and that in general, aside from narrow technicalities, he may helpfully join with his fellows from various walks of life in the effective study of a wide and important range of problems which lie outside the immediate limits of his own chosen field.

It is, in fact, perhaps not too much to say that as the engineering method, if we may so term it, is the more applied in our study of public questions, and broadly in that of the problems of life generally, so shall we be able to reach more sure and safe conclusions, and so will the engineer the more fully realize the degree of service which he may render to the cause of human progress.

(Continued on page 66)

First Henry Robinson Towne Lecture on the Relation between Engineering and Economics

The Vital Need for Greater Financial Support to Pure-Science Research

By HERBERT HOOVER, SECRETARY OF COMMERCE

I WISH on this occasion to say something upon our great national need of a much more vigorous support to pure-science research in our country.

There is no body of men more interested in the advancement of pure science than our engineers, for the engineering profession is built upon the application of scientific discovery. And of larger vision, if we would command the advance of our material and, to a considerable degree, of our spiritual life, we must maintain the earnest and organized search for truth. We could well put such an appeal wholly upon moral and spiritual grounds: the unfolding of beauty, the aspiration to knowledge, the ever-widening penetration into the unknown, the discovery of truth, and finally, as Huxley says, "the inculcation of veracity of thought." All are ample justification for our finding dollars to keep these searchers alive. But as I am proposing to support an appeal for dollars, I propose to discuss the dollars' results as well.

Research in the biological and physical sciences takes two forms, industrial research (which is the application of science) and research in pure science. Obviously there must first be a pure science before there can be an application. I am aware that there is a twilight zone between them, but no scientist has difficulty in finding the borders.

Our Nation Backward in the Development of Research in Pure Science

While we have in recent years developed our industrial research upon a scale hitherto unparalleled in history, we have by no means kept pace in the development of research in pure science. We have an increase in some ten years from 100 to over 500 laboratories engaged upon search for applications of known scientific fact and law. These results have been magnificent. But all these applied-science laboratories are dependent upon the raw material which flows from the laboratories and men engaged in pure science. And the industrial investigators are the first to demand more support to pure science.

Not only is our nation today greatly deficient in the number of men and equipment for this patient groping for the sources of fundamental truth and natural law, but the sudden growth of industrial laboratories has in itself endangered pure-science research by drafting the personnel of pure science into their ranks—depleting at the same time not only our fundamental-research staff, but also our university faculties, and thus to some degree drying the stream of creative men at the source. Thus applied science itself will dry up unless we maintain the sources of pure science. This is no complaint against our great industries and their fine vision of the application of science. It simply means we must strengthen the first line of our offensive. The day is gone by when we can depend very much upon consequential discovery or invention being made by the genius in the garret. A host of men, great equipment, long, patient, scientific experiment to build up the structure of knowledge, not stone by stone but grain by grain, is today the fundamental source of invention and discovery.

Compared with other expenditures of far less importance to human welfare, the amount of money annually devoted in the United States to the aid of investigators and investigation in pure science is absurdly small. It is less than one-tenth what we spend on cosmetics. We have indeed some fine foundations for pure scientific research. The Carnegie Institution, the Smithsonian Institution, the Rockefeller Institute, and the many other research activities of much more limited but special endowments, the work of our universities, together with the work of the National Research Council and our Government agencies, have shown fine accomplishment in this field. But the whole of the income available from these sources for research in pure science certainly does not exceed $10,000,000 a year, whereas in the professional schools of our universities, in technical and agricultural colleges and experiment stations, in industrial laboratories, and in our Government bureaus we probably expend today $200,000,000 a year upon applied-science research.

Scientific Work Seriously Impeded by Lack of Financial Resources

The wealth of the country has multiplied far faster than the funds we have given for these pure-science purposes. And the funds administered in the nation today for it are but a triviality compared to the vast resources that a single discovery places in our hands. Men of science know from their own experience how seriously scientific work has been impeded by lack of resources, and they will appreciate how great, in the aggregate, must be the resulting loss to the nation and to the world.

The progress of civilization, as all clear-thinking historians recognize, depends in large degree upon "the increase and diffusion of knowledge among men." It is not merely a question of applying present-day science to the development of our industries, the reduction of the cost of living, the eradication of disease, and the multiplication of our harvests, or even the diffusion of knowledge. We must add to knowledge, both for the intellectual and spiritual satisfaction that comes from widening the range of human understanding, and for the direct practical utilization of these fundamental discoveries. A special study in an industrial laboratory, resulting in the improvement of some machine or process, is of great value to the world. But the discovery of a law of nature, applicable in thousands of instances and forming a permanent and ever-available addition to knowledge, is a far greater advance.

Radio communication would have remained not merely impossible but wholly inconceivable except for the fundamental experiments of Faraday, the mathematical formulation of the wave theory by Maxwell, and the experimental realization of Maxwell's predictions by Hertz: successive advances in knowledge made without thought of immediate application or financial return.

No newspaper headlines noticed Becquerel's discovery of radio activity, from which long after sprung the whole train of discoveries leading to radium and its vast human service. No one reads in the popular journals of the theory of the hydrogen ion. We do hear sometimes of the effect in economy and production that its understanding is having upon scores of industrial processes, but how many know the name of the scientist who has added billions in money value to the world? And I am not sure he had even a stenographer to save his time in his race in search of other laws. The rise of the Einstein theory, which has revolutionized physical science and fundamentally affected modern thought, was rendered possible by the most abstruse developments of mathe-

Delivered at the Annual Meeting New York, November 30 to December 4, 1925, of The American Society of Mechanical Engineers.

matics over long terms of years, and who may say that some day it may not become the raw material of our industrial laboratories, with a fine outpouring of benefits in added human comfort and convenience?

GROUPS NEEDING GREATER SUPPORT IN THEIR PURE-SCIENCE RESEARCH

If we were to survey the nation we should find that the technically trained men engaged in pure-science research fall into two main groups: on the one hand, those supported in the great pure-science research institutions, and on the other, those in our universities or engaged in individual investigation. The number supported by our pure-science research institutions, such as the Carnegie, Rockefeller, Smithsonian, and others probably does not exceed 500 technically trained men. Those engaged in pure-science research in our universities or upon their own resources probably do not exceed 5000, and most of these devote only part of their time to this work. And there are some men in our industrial laboratories who are engaged in pure-science work. It is an interesting contrast that the scientifically trained personnel in applied-science investigation today is probably in excess of 30,000.

The problem as I see it is to secure much larger support—

1 To our university men, in order that they may be able to give a larger proportion of their time to research, and that our universities may increase the number of men;
2 To coördinated research for certain definite purposes;
3 To the pure-science research institutions.

It is on the men in independent research and in our educational institutions that the great burden of scientific advancement must always rest, and from them that the inspiration of the younger generation of oncoming scientific workers is derived. What we need above all things is the better support of these men. They should not, by the necessities of living and the cost of equipment, be forced into our industrial laboratories. Those men who show an aptitude for research should be less engulfed in teaching. Often their productivity can be greatly aided by being released from teaching and administrative demands, and endowed in research positions. Much can also be done by providing them with instruments, skilled assistants, measurers, computers, and stenographers, and all the aids that the nature of their researches and the most economical use of their time may demand. To attempt to herd them into great laboratories, even for pure research, is often their least useful service. To alter their mode of life and thought would merely result in the exhaustion at the source of the vital essence of their success. Moreover, the very researches which they prosecute and the discoveries they achieve demand just such concentration of attention and originality of perception as their freedom tends to foster.

THE INESTIMABLE VALUE TO THE WORLD OF INVESTIGATORS LIKE FARADAY

There is no price that the world could not afford to pay to these men who have the originality of mind to carry scientific thought great strides—and they wish no price. They need opportunity to live and work. No one can estimate the value to the world of an investigator like Faraday. Our whole banking community does not do the public service in a year that Faraday's discoveries do us daily. As national assets, men of his type, even when much less gifted than Faraday in the past and Millikan today, are beyond valuation, and no effort should be spared to facilitate their work. Only thus can they be reasonably expected to make the best use of their willingness to advance knowledge—and therefore civilization—without thought of personal gain.

The universities in which most of them are employed are not to be blamed for this, because they do maintain a vital interest in research and would be glad to devote much larger sums to its support if the pressure of other demands would permit. In seeking assistance elsewhere the investigator encounters ample good will, but sadly inadequate means. We may make these academic posts so attractive to the student of science that he will seek and occupy them permanently because of the opportunities they afford him to advance knowledge by original research without anxiety for bread and family and equipment. It is true that money cannot buy genius, but many a genius in science has defaulted because he has had to eat.

Aside from direct support to these men there is another method of organization of research among them that is no less in need of support. That is, coördinated research in specific directions by men in different localities—again, men mostly in our universities. Some of these are broad inquiries, demanding the joint consideration of specialists from various fields of science. Others are of narrowed scope but of such character or magnitude that the combined efforts of many workers are essential for their solution. The National Research Council has organized many coöperative investigations. Such organized campaigns against the unknown are few and far between in our country, for but few men have had the vision to give them financial support. Thus, we need to find great funds which, wisely directed, can be used to support and stimulate the work of the many indigent investigators, the many men in our universities, and the great research institutions, and to organize definite campaigns of coöperative research among them.

The third type of pure-science research that requires much more liberal support is the special institution. The recent appeal of the Smithsonian for additional endowment to enable it to support a larger staff so that it may properly compass that fraction of the field of science which has been its province, should have the support of every citizen. The Smithsonian has been peculiarly the architect of scientific investigation in our country. Much of the work we have in progress today has been inspired from this great pioneer of all American research.

It is unfortunately true that we can claim no such rank in pure-science research as that which we enjoy in the field of industrial research. Instead of leading all other countries in the advancement of fundamental scientific knowledge, the United States occupies a position far in the rear of the majority of European nations. A list of the awards of the Nobel prizes to men of various nationalities reveals the small proportion of first minds that we support. Other tests lead to the same conclusion, namely, that the number of first-rank investigators developed in the United States is far below what our population, education, and wealth would lead one to expect.

The difficulty we experience in securing a place in science beside the nations of Europe can hardly be due to a lack of men of innate ability, judging from the leading part already played by the United States in finance, in architecture, and in applied science. It results partly from the fact that American civilization is only beginning to emerge from the pioneering stage, and partly from the financial and other inducements which so often lead talented men reluctantly to accept well-paid industrial positions instead of poorly paid academic and research posts.

NEED OF ADEQUATE ORGANIZED FINANCIAL SUPPORT TO PURE SCIENCE RECOGNIZED BY LEADERS OF INDUSTRY

The far-sighted leaders of industry fully recognize the dependence of their progress upon advances in science, and emphasize their belief that fundamental research should be much more greatly aided. Dr. J. J. Carty said in his presidential address to the Institute of Electrical Engineers ten years ago:

> By every means in our power, therefore, let us show our appreciation of pure science, and let us forward the work of the pure scientists, for they are the advance guard of civilization. They point the way which we must follow. Let us arouse the people of our country to the wonderful possibilities of scientific discovery and to the responsibility to support it which rests upon them, and I am sure they will respond generously and effectively.

But the response has not yet come.

After many years of experience in industrial research he echoes the words of Tyndall spoken in New York in 1873:

> It would be a great thing for this land of incalculable destinies to supplement its achievements in the industrial arts by those higher investigations from which our mastery over Nature and over industrial art itself has been derived.

We have prided ourselves on our practicality as a nation. Would it not be a practical thing to do to give adequate organized financial support to pure science? And if by chance we develop a little contribution to abstract learning and knowledge, our nation will be immensely greater for it.

First Robert Henry Thurston Lecture on the Relation between Engineering and Science

Engineering and Science in the Metal Industry

Growth of Metal Industries since 1885—Selecting the Best Metal or Alloy for a Given Purpose—Factors Governing the Properties of an Alloy—Causes of Hardness in Steel—Effect of Science on the Metal Industry

By ZAY JEFFRIES,[1] CLEVELAND, OHIO

BECAUSE Robert Henry Thurston, first President of The American Society of Mechanical Engineers, and in whose honor this lectureship has been established, did so much to further engineering and science in the metal industry, it seems fitting that the first lecture should relate to this subject.

Before considering some of the engineering and scientific aspects of metals, I will present a brief perspective of the metal industry from the standpoint of production. While there are about fifty chemical elements used in industrial metals and alloys, the production of seven metals comprises more than 99.5 per cent of the total tonnage. These metals are iron, copper, lead, zinc, aluminum, tin, and nickel. The outstanding feature is that the production of iron alone comprises approximately 93 per cent of the total metal production of the world.

While some of the minor metals appear to be relatively insignificant if their annual production in weight is considered solely, they have a profound effect in present-day economics and industry. Gold of course occupies a unique place because of its general adoption as a money standard.

Although silver is one of our oldest metals, we could dispense with its old uses today far more readily than we could its use in photography. It is impossible to estimate the value of silver in photography. In this connection we have to consider not only the pleasure derived by nearly every human being from moving pictures and photographs, but also the enrichment of science and engineering.

Platinum is another metal which in spite of its high price is found to be more economical in certain commercial uses than any other available material. Examples are its use for high-temperature thermocouples, and as a catalyzer in the manufacture of sulphuric acid.

Chromium is a metal that is unused in the pure state, but it has been found to be invaluable as an ingredient in alloys used as resistors for electric furnaces and electric heating appliances. It confers upon the alloys the highly desirable property of improved resistance to oxidation at high temperatures. Chromium as an alloying ingredient in high-speed steel and stellite is of great importance. Its use as an electroplated protective coating on other materials has just begun. Chromium is the essential and principal alloying ingredient in stainless steels and in rustless irons. These materials have not yet made any substantial impression on the art, but they have considerable potentiality.

Tungsten is a material which has had a tremendous effect on modern industry. Its use as the principal alloying element in high-speed steel is well known to members of this Society. Since the development of high-speed steel by Taylor and White, the mechanical arts have been literally revolutionized. It would be impossible to determine the economic value of high-speed steel. But tungsten has another important application to which it is possible by the use of certain assumptions to assign a relative money value. In the present state of the electric-incandescent-lamp art the average efficiency during life of a tungsten-filament lamp is $4^1/_2$ times that of a carbon-filament lamp. Leaving out of consideration miniature lamps, there are consumed annually in the United States alone over 15 billions of kilowatt-hours of electrical energy for illumination, at a cost to the consumer of approximately $800,000,000. If the same level of illumination were maintained in the United States by the use of carbon lamps, assuming the same average cost of electrical energy to the consumer, an additional annual expenditure of about $2,900,000,000 would have to be made. Incidentally this amount of money would more than buy all of the pig iron and non-ferrous metals produced in the United States in a year. It is of course obvious that if we were still using carbon lamps we would not enjoy the present level of illumination. If we had, however, the present level of illumination with carbon lamps, and assuming no other material except tungsten to be available to replace carbon, we could afford to pay about $330,000 per pound for tungsten, and still obtain our light at the same cost. The actual cost of tungsten at the present time, in the ore, is less than a dollar per pound. This is only one illustration of the general proposition that the cost of a metal to the consumer is a function of its concentration in the earth's crust and its ease of recovery rather than of its value to industry.

Growth of the Metal Industries since 1885

The metal industry has been classified into two main groups, namely, the iron and steel or the "ferrous" group, and the "non-ferrous," which comprises all other metals. In considering the production of the various metals a good index is the production of new metal from ores. Pig iron is produced directly from iron ore, and consequently the annual production of pig iron represents fairly accurately the amount of new iron produced. In the production of steel a considerable quantity of scrap is used, so that the annual steel production is now greater than the annual pig-iron production. In the non-ferrous field metals are divided into primary metals mainly produced from the ores and secondary metals obtained by the reclamation of scrap material. Comparisons of production should not include the reclamation of scrap. In comparing the ferrous and non-ferrous metal industries I shall therefore consider the world production of pig iron and the world production of primary non-ferrous metals.

The world production of pig iron in the year 1800 was about 800,000 metric tons. The maximum world production of pig iron including the year 1924 was in 1913, when 79,100,000 metric tons were produced. Fig. 1 shows the world production of pig iron by five-year periods for the last forty years. It will be noted that the highest production occurred between 1910 and 1914, inclusive, and that the world production during the last five years was exceeded by each of the three previous five-year periods.

Fig. 2 shows the world production of pig iron for the last forty years in five-year periods in one column and the world production of all non-ferrous metals for the same five-year periods in another column, both charted to the same scale. This brings out strikingly the great preponderance of the iron and steel industry as compared to the non-ferrous metals industry as regards tonnage.

In the year 1800 about 7 tons of non-ferrous metals were produced for each 100 tons of pig iron. By 1850 the amount had been reduced to 5.85, and in 1880 to 4.37 tons of non-ferrous metals for each 100 tons of pig iron. The accelerated pig-iron production during this period obviously reflects the advent of the open-hearth and bessemer processes for converting pig iron into steel, and the tremendous growth of the railroads and other industries in which iron and steel were the chief construction materials.

[1] D.Sc. Consultant, Aluminum Company of America, Incandescent Lamp Dept., General Electric Co., and National Tube Co.

Delivered at the Annual Meeting, New York, November 30 to December 4, 1925, of The American Society of Mechanical Engineers.

In order to obtain an idea as to the relative growth of the ferrous and non-ferrous metal industries during the last forty years, Fig. 3 has been prepared in which the non-ferrous metal production is charted to a scale twenty times that of the production of pig iron. It will be noted that the production of pig iron has been substantially greater than twenty times that of the non-ferrous metals for the first thirty years of the period covered, namely, from 1885 to 1914, inclusive, whereas during the last ten years the production of pig iron has been considerably less than twenty times that of the non-ferrous metals. The average of the forty years is 5.09 tons of non-ferrous metals for each 100 tons of pig iron produced, whereas in the periods 1915 to 1919 and 1920 to 1924, inclusive,

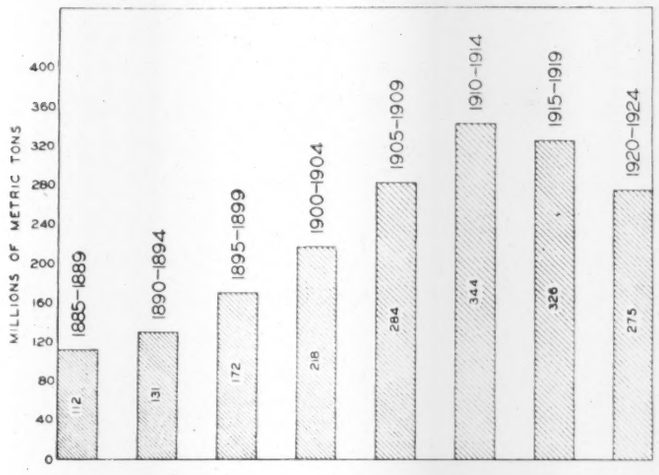


FIG. 1 WORLD'S PRODUCTION OF PIG IRON FROM 1885 TO 1925 BY FIVE-YEAR PERIODS

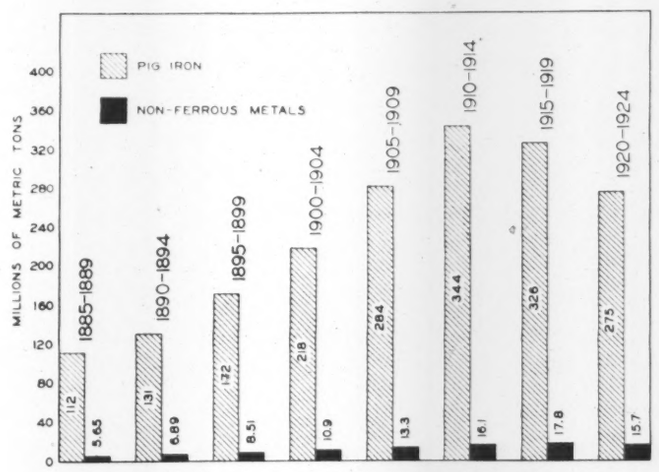


FIG. 2 WORLD'S PRODUCTION OF PIG IRON AND NON-FERROUS METALS FROM 1885 TO 1925 BY FIVE-YEAR PERIODS

5.47 and 5.70 tons, respectively, were produced for each 100 tons of pig iron.

In 1924, 6.44 tons of non-ferrous metals were produced for each 100 tons of pig iron, which represents the largest ratio for more than seventy-five years. Furthermore, the world production of pig iron for 1924 (63,900,000 metric tons) was exceeded in eight separate previous years, namely, 1910, 1912, 1913, 1915, 1916, 1917, 1918, and 1923. On the other hand, the production of non-ferrous metals in 1924 was the largest in history (4,116,000 metric tons), exceeding the 1917 production by about 5 per cent.

HEAT TREATMENT AND ALLOY-STEEL PRODUCTION

There are two changes going on within the iron and steel industry which are of great interest to the engineer because they are largely due to his activities. Each year there is a larger proportion of the steel production subjected to heat treatment. Automotive production has been a tremendous stimulus in this direction, but the increase is not by any means confined to that industry; it is general.

Stark[2] has estimated that in 1924 there were from 3,000,000 to 3,500,000 gross tons of steel heat-treated in the United States.

The other change is in the production of alloy steel. In 1909 there was one ton of alloy steel produced for every 131.6 tons of total steel in the United States. In 1924 there was one ton of alloy steel produced for every 18.7 tons of total steel produced.[3] The amount of alloy steel produced in 1924 in the United States alone was over 2,000,000 tons. Whereas the total steel production of the United States was about 56 per cent greater in 1924 than in 1909, the alloy-steel production was about 995 per cent greater in 1924 than in 1909. Stating these facts in another way, the alloy-steel industry in the United States has grown during the last fifteen years about 18 times as rapidly as the total steel industry.

What is the significance of these statistics? Our industrial civilization is undergoing a change. In the Commerce Year Book for 1924, page 395, is found the following statement: "Railway tonnage and freight tonnage originating have not changed greatly since 1913." There is being produced relatively less rolling stock with iron-alloy wheels running on steel rails and more with rubber tires running on pavement. More power is being transferred by electrons and less, relatively, on wheels. The electrical and communication industries have grown to immense proportions. Radio seems to be fairly well launched, and the aircraft industry is striving for recognition. The effect of these changes on the metal industry is manifold. Two main changes stand out.

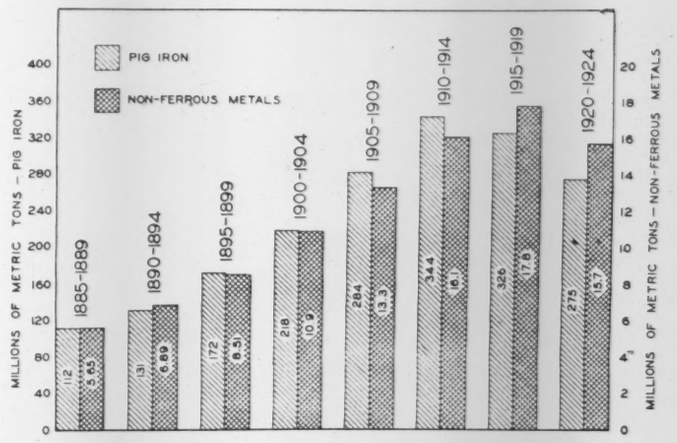


FIG. 3 WORLD'S PRODUCTION OF PIG IRON AND NON-FERROUS METALS FROM 1885 TO 1925 BY FIVE-YEAR PERIODS
(Non-ferrous metals charted to scale 20 times that for pig iron.)

Firstly, in all of the industries means are being devised to make a pound of metal render more service. Steel rails made thirty years ago, for example, would wear out quickly under modern high-speed and heavy-duty conditions. Modern rails will carry more pounds of freight per pound of steel. More electrical energy is transmitted through a given weight of wire by the use of higher voltages.

In the second place, as industry becomes more complicated there is a greater demand for metals and alloys with various special properties. Since iron represents only one element and since there are a number of non-ferrous metals available, it is not surprising that the latter should be found capable of fulfilling an increasing proportion of these special requirements.

THE PROBLEM OF SELECTING THE BEST METAL OR ALLOY FOR A GIVEN PURPOSE

One of the great problems of the engineer is the selection of the best material for a given purpose. It has been estimated that more than 5000 metals and alloys of different chemical composition are in use. In some instances the same compositions are used in the form of castings and in the worked condition. Worked metals of a given composition are produced with a variety of physical properties, depending upon the type of heat treatment and the degree of strain hardness imparted by cold work. Either cast or

[2] The Proportion of Heat-Treated Steel to Total Production, C. J. Stark, A.S.S.T. September Meeting, 1925.

[3] E. F. Cone, *The Iron Age*, September 3, 1925.

worked metals may be subject to a substantial change of properties by heat treatment, and in many cases a number of separate heat treatments may be applied to a material of a given composition. Various methods of casting and working impart different characteristics to a metal. With such complexity it might seem almost hopeless to select the best metal or alloy for a given purpose.

The selection is a most complex problem. In many instances there is only one base metal deserving of consideration because of the cost, quantities available, shapes and sizes, and properties required. One does not need engineering training to determine that steel is the proper material for rails. Engineering experience is required, however, to select the proper kind of steel and the proper treatment so that the rails will have suitable integrity and life. For certain electrical purposes copper is as obvious a selection as steel is for rails.

But in other instances the engineer must make his selection from two or more metals. Assuming that several materials will function suitably in service, the selection should be made on the basis of ultimate economy. This may be referred to as selection by *economic compromise*.

Some factors in the economic compromise are obvious, but others are subtle. It seems obvious, for example, that brass should be selected in place of steel for a small part requiring so much machining that the saving in cost of machining of the brass together with the higher sale price of borings more than offsets its higher first cost: the cost of the finished part is less in brass than in steel. It is not so obvious to some, however, that brass should be selected in many cases, even though the direct cost of the finished part is greater than that of steel. The use of brass will result in a greater output per machine, which may result in the production of a greater number of completed units of which the brass piece is a part. The increased production of completed units may result in an economy out of all proportion to the slight increase in cost of the brass as compared to the steel piece. It has been my observation that the most successful manufacturers take advantage of these subtle economic compromises.

FIG. 4 SHOWING HARDENED SURFACE OF PURE IRON HEATED TO 1450–1500 DEG. CENT. IN A HYDROGEN ATMOSPHERE AND QUENCHED IN OIL (SYKES AND TARASOV)

But the selection of material is even more important from the standpoint of the quality of service to the consumer than it is in the direct manufacturing cost. Here the economic compromise must take into consideration that which will behave best in service. That which serves well should be used much, and being used much the manufacturer should derive an ultimate benefit from mass production which might far outweigh small differences in the cost of materials.

What is the engineer doing today to more nearly approach the ideal economic compromise in the selection of materials? One has only to visit a number of modern factories to be impressed with the tremendous amount of testing that is now going on. Usually a machine is unsatisfactory because of a few weak features, and most of the experimental effort is directed toward strengthening these parts. The various parts of a machine are tested separately, and the assembled device is tested as a unit. Both laboratory and use tests are made. The result of all these tests is a more thorough understanding of the requirements for a given purpose, and a better selection and adaptation of the materials. The engineer of today is better able to approach the ideal economic compromise in the selection and use of material than was the engineer of yesterday.

The engineer is confronted with a difficult task in the adaptation and selection of metals for various uses, even with the metals and alloys now available. But metals and alloys with new and improved properties are currently being made available for his use. New processes for fabricating metals are being developed and old ones are being improved. Any such new material or process may disturb the economic balance. A change from a machined part to a die casting probably not only results in a reduction in the machine-tool requirements and change of machine type, but also in a change of material from, say, iron, steel, or brass to an aluminum or zinc alloy. The engineer's already difficult tasks are made even more difficult by a constant change in the state of the metal art. The progressive engineer should not only have a thorough understanding of services to which metals are to be put, but he should have also a general understanding of the properties of metals and alloys.

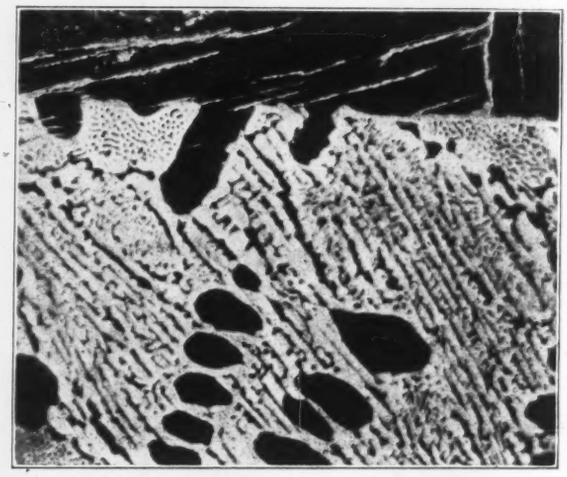


FIG. 5 SHOWING FINE-GRAINED WHITE-CAST-IRON STRUCTURE OF SURFACE OF PURE IRON SPECIMEN HEATED IN A HYDROGEN ATMOSPHERE AND QUENCHED IN OIL (SYKES AND TARASOV)

CONTRIBUTIONS OF SCIENCE TO METAL ART

We must recognize the great contribution of metal art to metal science. Even today metal art is contributing generously to metal science, but up to about fifty years ago it may be said that the metal industry was all art and no science. It is largely because of science and engineering that the metal industry has progressed more in the last fifty years than in the previous 10,000 years. One of the chief factors in the advancement of science is the time required to correlate and interpret observations. The following example will illustrate this point. It is well known that pure iron cannot be made hard by quenching from a high temperature. W. P. Sykes[4] found that pure iron heated to 1450–1500 deg. cent. in a hydrogen atmosphere and quenched in oil was glass-hard, in fact, as hard as the hardest steels. When quenched in water the iron was soft. If heated in an air atmosphere in place of hydrogen the iron was soft whether quenched in oil or water. An hour's investigation with the microscope reveals the explanation. Fig. 4 shows that the surface of the iron has a different structure from the interior. The surface portion only is hard.

Fig. 5 shows that the surface portion represents a typical fine-grained white-cast-iron structure. In fact, most of the surface layer has been melted during the quench. This seems anomalous, but it is a fact. The surface of the iron is clean because of the hydrogen atmosphere in the furnace. When this clean hot iron strikes the oil, some of the carbon from the oil combines with the iron

[4] Metallurgist, Cleveland Wire Works, Incandescent Lamp Department of General Electric Company.

rapidly. Addition of carbon to iron lowers its melting point. The melting point of pure iron is 1530 deg. cent. and that of an iron-carbon alloy containing about 4 per cent carbon is 1130 deg. cent. Before the iron can cool from 1450 deg. cent. to 1130 deg. cent. enough carbon is absorbed at the surface to melt a thin layer of the iron-carbon alloy. The figure shows that carbon has penetrated a short distance into the solid iron.

If this observation had been made, say, in the year 1, several centuries might have elapsed without interpretation. Modern science has provided the knowledge and equipment which permits of an interpretation without delay. The rate of advance of science is determined in no small degree by the elapsed time between observation and interpretation.

CLASSIFICATION OF METALS AND ALLOYS

It was mentioned above that there may be as many as 5000 metals and alloys of different chemical composition in use. These materials are usually classified with reference to the predominating metal. Iron-base alloys comprise all of those alloys in which iron is the principal metal. Similarly we have the copper-base, lead-base, aluminum-base alloys, etc. Fifteen metals comprise the bases for nearly all of the 5000 varieties.

The study of the constitution and crystalline structure of metals and alloys by means of the microscope, X-ray spectrometer, thermal analysis, chemical analysis, and various physical tests has resulted in a classification with reference to the manner of aggregation of the constituent atoms.

There are three classes, namely,

1 Pure, or substantially pure, metals
2 Solid solutions, and
3 Compounds.

A pure metal is what the name implies, that is, a metal composed substantially of one kind of atom. Compounds found in metals are usually of the metallic variety and represent a combination in definite proportions of two or more varieties of atoms. Not only are the atoms in definite proportions, but the metallic compound has a distinctive form of crystal structure. The common solid solutions represent gradual departures in properties as compared to the base or solvent metal. For example, if copper is added to nickel the properties vary somewhat from those of nickel, and the variation is greater the greater the amount of copper; the alloy would be classed as a solid solution of copper in nickel. It has been found that the atoms of copper replace atoms of nickel in the crystal space lattice. If nickel is added to copper, the properties of the copper are changed to an extent depending on the amount of nickel added, and the resulting alloy is said to be a solid solution of nickel in copper. Solid solutions, however, may have compounds as well as pure metals as the principal or solvent material.

Any alloy, no matter how complex, is made up of one or more of the above-named constituents (pure metal, solid solution, or compound), and it is the problem of the metallurgist to be able to identify these various constituents by one means or another. It is also his problem to try to ascertain the properties of each constituent separately, because only by so doing is he able to determine the approximate effect of each constituent on the properties of an alloy. There is much yet to be found out about the most common pure metals with respect to the relation between structure and physical properties. There is still more to be ascertained regarding the properties of solid solutions and compounds.

FACTORS GOVERNING THE PROPERTIES OF AN ALLOY

The properties of any alloy will depend upon:

1 The number and properties of the constituents present
2 The proportions of the constituents, and
3 The arrangement of the constituents.

The first step in the understanding of alloys is an understanding of pure metals. When a pure metal solidifies, the unordered arrangement of the atoms, characteristic of the liquid state, is changed to an ordered arrangement of the atoms known as the crystalline state. There are six fundamental types of crystal structures, three of which have been found in pure metals. The modern method of considering crystal structure is in terms of space lattices. A space lattice consists of a series of points in space such that every point is situated similarly to every other point. Space may be imagined as divided into cells by three sets of parallel planes, the intersections of these planes constituting the points of the space lattice.

A solid metal may be composed of a single crystal, or, more commonly, of a large number of differently oriented crystalline units called "grains." The mechanical properties of a single crystal are decidedly different from those of a piece of the same metal composed of a large number of grains. A crystal has different properties in different directions. These are known as "directional" properties and are due to the crystallographic planes arising from the ordered arrangement of the atoms. A single crystal of a metal tested in tension may show only half the tensile strength of a piece of the same metal with a fine-grained structure. The metal with a fine-grained structure may have its tensile strength again doubled by cold working. The cold-worked metal will be composed of the same kind of atoms as the single crystal, yet its tensile strength may be four times as great. Such facts show that the arrangement of the atoms in a metal is all-important in determining the physical properties.

The Brinell hardness number of pure iron in the form of large crystals may be as low as 60; that of hard steel may be higher than 600. The composition of the hard steel may be 99.3 per cent iron and 0.7 per cent carbon. It is obvious that with so small a quantity of carbon it would be possible to search out a relatively short path of rupture between iron atoms alone in the hardened steel. Why is it that the iron atoms are apparently held together with greater force in the hardened steel than they are in pure iron? It is not necessary to assume a greater attraction between iron atoms in hardened steel than in pure iron to account for the great disparity in hardness. These properties can be explained on the basis of a substantially constant attraction between the iron atoms and variations in their arrangement.

SLIP PLANES

The sum of the atomic attractions on a plane through a piece of metal normal to the stress may be called the "absolute cohesion" of the metal.[5] Observed tensile strengths are always very much lower than the absolute cohesion. In fact, the atomic attraction in a piece of pure metal is sufficient to account for the maximum hardness attainable by cold work or even by alloying. The softness and weakness of pure metals obtain in spite of the relatively high absolute-cohesion values. The key to this interpretation is found in the crystalline structure. Permanent deformation of a solid metal is now known to take place largely by slippage of one portion of a crystal with reference to another along crystallographic planes. Such planes on which slip has taken place are called "slip planes," and other planes on which slip may take place may be referred to as "potential slip planes." Slip begins in a crystal at a load which is very small as compared to the absolute cohesion normal to the slip plane. The atoms are supposed to be held together by electromagnetic forces, and as slip progresses many of the attractive bonds between atoms are not permanently broken but are transferred from one atom to the next. It may be only the atoms at the ends of a slip plane, namely, at the boundaries of a crystal, that are permanently broken, and these represent a very small percentage of the total atoms on the plane. The extent of slip in ordinary deformation varies all the way up to, say, 5000 atom diameters for one slip movement. Many slips may, however, in severe permanent deformation such as cold rolling or wire drawing, occur on the same plane.

A test piece composed of a single crystal so oriented that planes of easy slip are at a favorable angle for shear with reference to the direction of stress, would offer the least possible resistance to slippage. There is substantially no permanent slip within the elastic limit of a metal, so the beginning of slip corresponds to the elastic or proportional limit.

The slippage of one part of a crystal on another may be compared to the sliding of a piece of iron on a smooth magnetized surface. It takes much less force to slide a piece of iron on a smooth magnetized surface than to pull the piece of iron directly away from such surface. The force required to pull the piece of iron directly away from the magnetized surface may be compared to the absolute cohesion of atoms normal to a slip plane, and the force required to

[5] Jeffries and Archer, The Science of Metals.

slide the piece of iron on the smooth magnetized surface may be compared to the force required to produce slip along the plane. It is thus seen that the crystalline structure gives rise to planes of weakness with reference to slip movement, which is the cause of the relative softness of pure metals. Hardening of a metal results from any change in structure which increases resistance to slip.

There are a number of common ways of increasing slip interference in a metal or alloy. In a pure metal the simple way to increase slip interference is by grain refinement. The area of each slip plane is restricted to the cross-section of the crystal or grain in which slip occurs. Adjacent grains in a multi-crystalline specimen have different orientations. The orientation of a crystal is determined by the directions of its crystallographic planes. In a single crystal the portions on either side of a slip plane are free to move during slip, so that the force required to produce slip depends entirely on the frictional resistance of the atoms within the crystal itself. In a multi-crystalline specimen, on the other hand, a grain is completely surrounded by other grains, and slip cannot take place in such a surrounded grain without simultaneous movement in adjacent grains to accommodate the displacement. Resistance to slip in such a surrounded grain is therefore greater than that in a single crystal similarly oriented with respect to the stress, because the interference to slip is equal to the sum of the resistance within the grain itself and that of the surrounding grains. In a multi-crystalline specimen slip must take place simultaneously in many grains. Some of the grains will be so oriented that slip must take place on planes which offer high resistance with reference to the direction of the stress. These conditions combine to increase slip interference as the grain size is reduced. Very high hardness values may result from extreme grain refinement.

Cold work is essentially a mechanical means of destroying the perfection of crystal structure and thereby increasing slip interference, with consequent increased hardness and tensile strength.

Slip planes which may be regarded as comparatively smooth in a pure metal may be said to be roughened by the formation of a solid solution. It is probable that in a solid solution the unlike atoms have greater attraction for one another than the like atoms. There is often also a disparity in atomic size which would cause "roughening" of the slip planes. In solid solutions slip resistance on the crystallographic planes is increased as compared to the pure metal or solvent, but the planes usually permit of slippage. Solid solutions with a soft-metal base or solvent, unless very fine-grained, are never very hard.

Metallic compounds, on the other hand, are characteristically hard, that is, the resistance to slip on crystallographic planes is very high. This is considered to be due to the fact that the crystalline symmetry is usually low in the metallic compound as compared to pure metals and because the compound is made up of different kinds of atoms, each kind having its definite place in the crystalline lattice. Also the attraction between these unlike atoms must be high in order for a metallic compound to form. In a pure metal, and to a large extent in a solid solution, the atoms are interchangeable as to position. The non-interchangeability of the unlike atoms in a metallic compound should be unfavorable to slip. A slip of one atom diameter may destroy the system of the atomic bonding within a compound, and new bonds with the same cohesive force as the old bonds cannot readily form. Fracture occurs along the crystallographic planes, and the material is said to be brittle.

HARD METALLIC COMPOUNDS IMPORTANT FACTORS IN DEVELOPING SLIP INTERFERENCE

Hard metallic compounds are important factors in the development of slip interference in alloys. Let us consider a specific example. The Brinell hardness number of nearly pure aluminum, wrought and annealed, is about 20. The addition of copper gradually increases the hardness, so that when 5 per cent of copper is present in the form of solid solution the Brinell hardness number may be increased to about 70. In order to obtain 5 per cent of copper in solid solution in aluminum it is necessary to heat the alloy to a temperature of about 530 deg. cent. and quench. If the alloy is slowly cooled from 530 deg. cent. some of the copper combines with aluminum to form a metallic compound $CuAl_2$. This compound is itself hard, but is precipitated in relatively large particles which do not offer maximum interference with slip. The resulting hardness may be as low as 40. If the quenched alloy containing 5 per cent of copper in solid solution is reheated to a temperature of 150 deg. cent. or thereabouts, some of the compound precipitates in the form of myriads of fine particles and the Brinell hardness number may be increased from 70 to more than 120. If the temperature of reheating is increased so that the particles of $CuAl_2$ become larger than a certain size the hardness is again reduced. There is a certain size of precipitated particle which produces maximum hardness. This general proposition was put forward by Merica, Waltenburg, and Scott[6] as an explanation of the age hardening of the strong aluminum alloy known as "duralumin." This explanation has proved to be correct, and it represents a distinct advance in the science of metals.

The grain size in the aluminum-copper alloy is relatively coarse. The precipitation of the $CuAl_2$ takes place largely within the crystals themselves. The degree of fineness of the $CuAl_2$ precipitate which is required to produce maximum hardness is referred to as "critical dispersion." These particles are considered to be so small that about 10,000 of them would have to coalesce into one particle to be resolvable under the highest-powered microscope.

A mechanistic interpretation of the cause of this phenomenon has been put forward.[7] Fig. 6 represents schematically a section through a crystal of solid solution, the black circles representing the solvent atoms and the white ones the solute atoms. This structure is hard as compared to one composed entirely of solvent atoms, because of the greater attraction between unlike atoms as compared to like atoms and because of the relatively poor fit of the solute atoms in the space lattice. The resistance to slip along the planes has been increased by the presence of the solute atoms, but the planes are nevertheless intact. This figure represents a solid solution crystallizing with a cubic lattice, the proportion of solute atoms being 14 per cent. Fig. 7 represents the condition in which a portion of the solute material has combined with solvent material to form a hard metallic compound with a hexagonal crystal structure. The solid solution remaining contains only 7 per cent of solute atoms. The compound contains two atoms of solvent to one of solute. It will be seen that the effect of these particles is to key the slip planes. When it is considered that an average slip in a pure metal or a solid solution is from 500 to 1000 atom diameters, it seems apparent that the presence of such a large number of small hard particles would offer greater interference to slip than if the solute particles were in solid solution. In fact, the matrix of the alloy after the precipitation of some of the metallic compound is softer than before such precipitation because it contains less dissolved material. The increased hardness of the alloy is the algebraic sum of the very great hardening effect of the precipitated compound and the reduction in hardness of the matrix due to the loss of solute atoms.

When conditions permit, such as high temperature and long exposure, the tendency is for the particles of metallic compound to become fewer in number and larger in size. Fig. 8[8] represents the same alloy in which all of the particles shown in Fig. 7 have grown into one larger particle. Such changes take place in solid alloys far below the melting point because the large particles represent a greater degree of stability and the solute atoms are able to diffuse in the crystal lattice of the solvent. It can readily be seen that potential slip planes which can avoid the hard particle are much greater in expanse than those shown in the previous figure; consequently the material is softened by the growth of the particles of the metallic compound.

Some important heat-treated commercial aluminum alloys owe their high hardness and strength to the fine precipitation of intermetallic compounds from quenched supersaturated solid solutions.[9]

The art of hardening steel seems to be at least three thousand years old, and more likely older. Many conjectures have been made as to the cause of its hardness and as to the mechanism of hardening.

---

[6] Trans. A.I.M.E., vol. 64 (1920), p. 41.

[7] Jeffries and Archer, Slip Interference Theory of the Hardening of Metals, *Chemical & Metallurgical Engineering*, June 15, 1921.

[8] I am indebted to A. B. Gladding for the preparation of the original drawings from which Figs. 6, 7, and 8 were made.

[9] Streeter and Faragher, MECHANICAL ENGINEERING, 1925, p. 433. E. Blough, Proc. A.S.T.M., vol. 24 (1924), p. 258.

Archer and Jeffries, New Developments in High-Strength Aluminum Alloys, A.I.M.E. February Meeting, 1925.

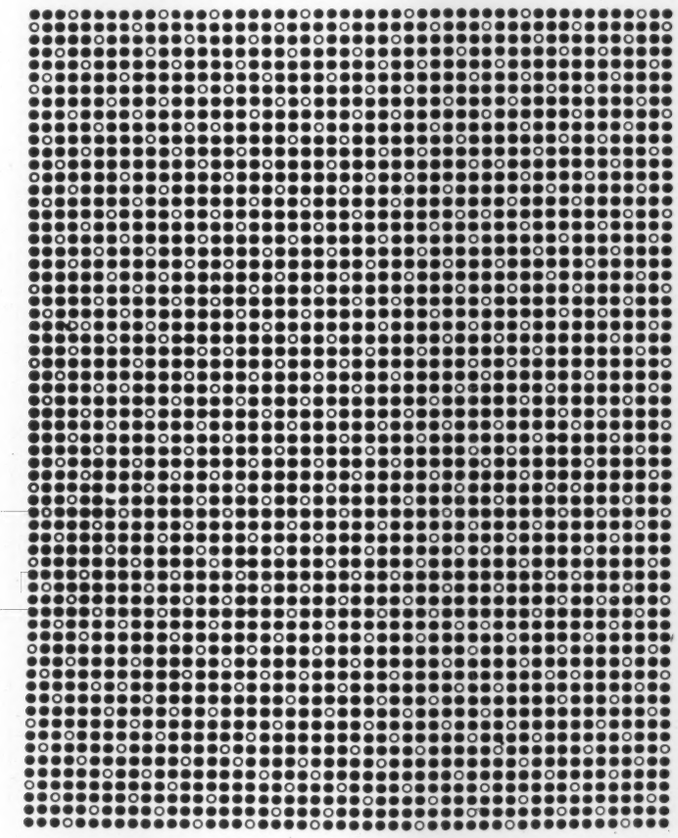


FIG. 6 SCHEMATIC REPRESENTATION OF A SECTION THROUGH A CRYSTAL OF SOLID SOLUTION

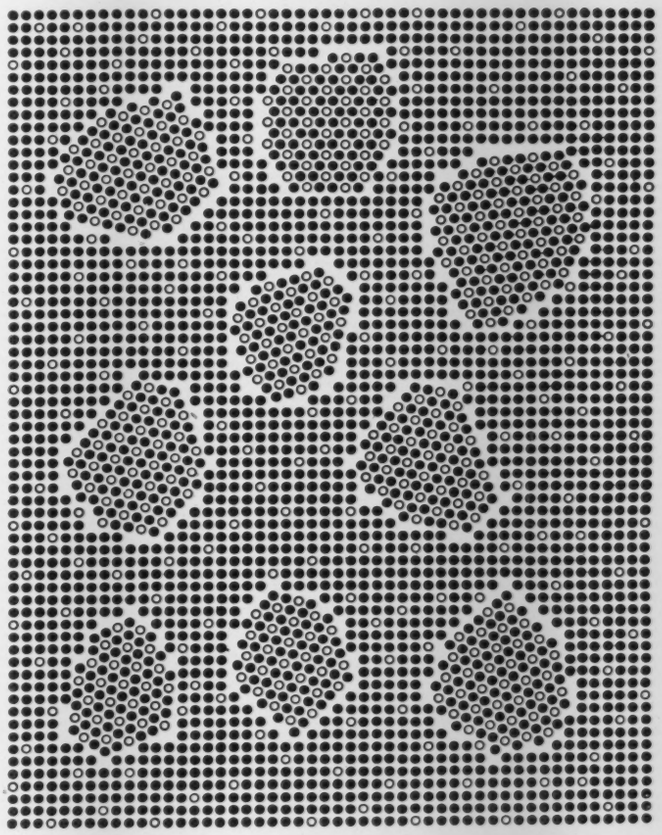


FIG. 7 REPRESENTING CONDITION IN WHICH A PORTION OF THE SOLUTE MATERIAL OF FIG. 6 HAS COMBINED WITH SOLVENT MATERIAL TO FORM A HARD METALLIC COMPOUND WITH A HEXAGONAL CRYSTAL STRUCTURE

The study of this question has been particularly active during the last forty years. By applying many of the known tools of science in the study of the hardness and hardening of steel, and by utilizing the results of many researches, it is now believed that a satisfactory explanation has been found. Like all explanations, there is much yet to be found out regarding minute detail, but it is believed that the general statement of the cause of the hardness and mechanism of hardening of steel is correct.

CAUSES OF HARDNESS IN STEEL

At the outset it may be said that steel owes its great hardness essentially to the high attractive forces between the iron atoms, and that the mechanism of hardening is one which so arranges the iron atoms as to greatly interfere with slip on the crystallographic planes, or in extreme cases to so interfere with slip that rupture of the piece precedes any substantial permanent deformation.

Let us first consider briefly the mechanism of the hardening. Pure iron exists in the solid state in two distinctly different types of space lattice. One known as the "face-centered" cubic space lattice, stable between about 1400 deg. cent, and 900 deg. cent., is called "gamma iron." Solid solutions with gamma iron as the solvent are referred to generically as "austenite." The other crystal form of iron is the "body-centered" cubic space lattice, stable below 900 deg. cent. and between about 1400 deg. cent. and the melting point of iron, 1530 deg. cent. The latter variety of iron below 900 deg. cent. is called "alpha iron," and is the variety obtaining in most iron and steel at ordinary temperatures. Carbon is more soluble in gamma iron than in alpha iron, readily dissolving in the former up to about 1.7 per cent at 1130 deg. cent. The solubility decreases with temperature, so that 0.9 per cent carbon is soluble in gamma iron at about 700 deg. cent.

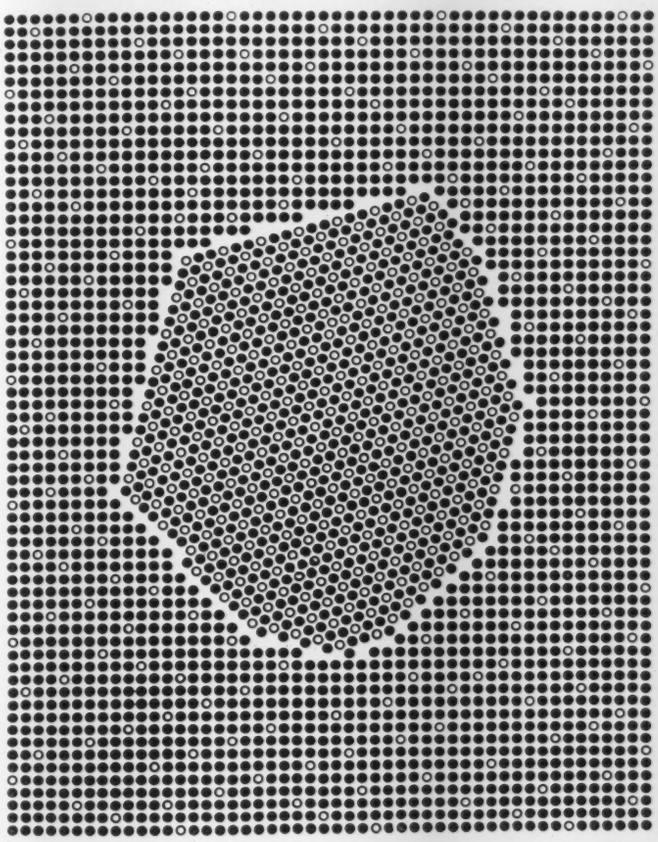


FIG. 8 REPRESENTING CONDITION IN WHICH ALL OF THE PARTICLES OF FIG. 7 HAVE GROWN INTO ONE LARGER PARTICLE

For simplicity we may consider a steel containing 0.9 per cent carbon in the gamma-iron or austenitic condition at a temperature somewhat above 700 deg. cent. When this steel is allowed to cool in the air the solid solution decomposes, forming nearly pure alpha iron and a metallic compound, Fe_3C, called "cementite." Fig. 9 shows the structure of such

an air-cooled specimen. This structure, called "pearlite," represents a considerable increase in hardness as compared to pure iron because the hard cementite interferes with slip in the iron crystals. The Brinell hardness number is of the order of 225. If, instead of air cooling, the solid solution of carbon in gamma iron is quenched, the steel becomes glass-hard and a characteristic structure is produced, known as "martensite." Martensite has long been recognizable under the microscope due to the characteristic acicular or needle-like structure as shown in the Fig. 10.

With slow cooling the decomposition of the austenite takes place in the neighborhood of 700 deg. cent. The carbon atoms are most likely dispersed atomically in the austenite. When the decomposition takes place at about 700 deg. cent. the carbide forms simultaneously with the transformation of the gamma iron to alpha iron. When the steel is quenched, that portion which changes to

FIG. 9 PEARLITIC STRUCTURE OF HIGH-CARBON STEEL COOLED IN AIR FROM GAMMA-IRON CONDITION (WALP)

FIG. 10 MARTENSITIC STRUCTURE OF HIGH-CARBON STEEL QUENCHED FROM GAMMA-IRON CONDITION (WALP)

martensite undergoes no transformation until a temperature of about 300 deg. cent. is reached. At this temperature the gamma iron changes to alpha iron with increase in volume because the alpha-iron space lattice does not represent as close packing of the atoms as the gamma-iron space lattice. No substantial volume change takes place at 700 deg. cent. when the austenite is allowed to change slowly over to alpha iron and cementite, because the contraction due to the carbide formation is nearly sufficient to compensate for the expansion due to the transformation of the iron. It has now been found that the gamma-to-alpha-iron transformation takes place on the formation of martensite, but that the carbide formation is substantially arrested, the carbon atoms being largely trapped in atomic dispersion. Freshly formed martensite may therefore be regarded as a supersaturated solution of carbon in alpha iron.

It is the belief of a number of metallurgists that the hardness of martensite is due to the presence of the carbon in solid solution in alpha iron. The X-ray spectrometer, a scientific tool recently developed, was used to definitely determine that martensite consisted essentially of alpha iron, but X-rays gave another indication, namely, that the alpha-iron grains were exceedingly small. Incidentally the first X-ray results indicated that the grains were small because the width of the diffraction lines was greater than that obtained with materials of ordinary grain size. It has later been pointed out that the greater width of diffraction lines may be due to strains or to different degrees of concentration of carbon in different grains or in different portions of the same grain. However, a still more recent investigation has shown that an original austenite grain representing one orientation may produce, on quenching, alpha-iron grains with tens of thousands of different orientations. Each different orientation either represents a separate grain or, in so far as slip interference is concerned, is analogous to a separate grain. It can therefore be said with more assurance that the alpha iron in martensite is exceedingly fine-grained, in fact finer-grained than any structures produced by ordinary metal-working and heating processes. It is therefore very probable that the extreme hardness of freshly formed martensite is due largely to the grain refinement and to a less extent to the carbon in solid solution.

Martensite appears to harden somewhat on room-temperature aging and more quickly on mild tempering, say, at 100 deg. cent. Fig. 11 shows the results of Honda and Idei on the scleroscope hardness of martensite aged at room temperature. The carbon in the freshly formed martensite is in an unstable condition because the alpha iron is greatly supersaturated. The slight increase in hardness is probably due to the precipitation of the carbide into particles approximating critical size for maximum hardness. Further tempering of martensite beyond the point where the carbide is critically dispersed for maximum hardness reduces the hardness rapidly both by growth of the cementite particles and by growth of the alpha-iron grains.

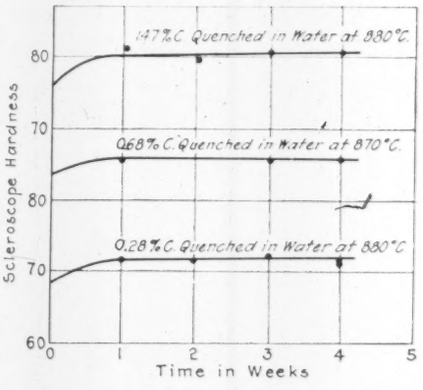


FIG. 11 SCLEROSCOPE HARDNESS OF FRESHLY FORMED MARTENSITE AGED AT ROOM TEMPERATURE (HONDA AND IDEI)

In the aluminum alloys the precipitation of the intermetallic compound from the supersaturated solid solution sometimes more than doubles the hardness. Why does the precipitation of the carbide in freshly formed martensite cause such a slight increase in hardness? This is probably due to the fact that nearly maximum hardness may be developed by either super grain refinement or by critical dispersion of the hard metallic compound. The grain refinement alone in martensite is sufficient to bring the hardness nearly up to the maximum obtainable in an iron alloy, and consequently the precipitation of the carbide has but a moderate effect.

The precipitation of the carbide in freshly formed martensite apparently proceeds for a long time at room temperature, with spontaneous generation of heat due to the heat of formation of the carbide and with spontaneous shrinkage due to the fact that the iron and carbon atoms form a closer-packed arrangement in the carbide than when the carbon is atomically dispersed in the alpha iron. Brush[10] was able to observe the spontaneous generation of heat in quenched steel to such an extent that in a sensitive calorimeter the temperature of the steel itself was increased over 2 deg. cent. and the heat evolution was still sufficient to be measured at the end of five weeks. All of you have heard of quenched steel spontaneously rupturing at any time from a few seconds to a few weeks after quenching. This phenomenon is no doubt due to the spontaneous shrinkage occurring in freshly formed martensite. The quenched piece of steel will have the martensite more completely

[10] C. F. Brush, Trans. A.I.M.E. (Pyrometry Volume), 1920, p. 590.

formed in the outer shell than in the interior. The rate of cooling of the interior portion is such that its structure corresponds somewhat to that of quenched and highly tempered steel. The outer shell, being more completely martensitic, begins contraction as the carbide forms. This contraction sets up tension stresses in the outer shell and eventually these tension stresses may exceed the strength of the material, at which time spontaneous rupture occurs sometimes with great violence.

HIGH-SPEED STEEL

These ideas as to the cause of hardness have been extended to account for the hardness of high-speed steel.[11] In order for the iron carbide to form at room temperature in freshly formed martensite, it must be possible for the carbon atoms to diffuse in iron at that temperature. This seems probable because the carbon atom is very small as compared to the iron atom. On the other hand, high-speed steel contains considerable quantities of tungsten, chromium, and vanadium, tungsten having the largest atom of any of the alloying elements present. Fig. 12 shows the relative sizes of the atoms present in high-speed steel. Furthermore the carbide containing tungsten is the most stable of all of the carbides which may possibly form in high-speed steel. The tungsten atom is so large that it cannot readily diffuse in the iron space lattice until a temperature of approximately 500 deg. cent. is reached. When the steel is quenched from a high temperature a considerable portion of the

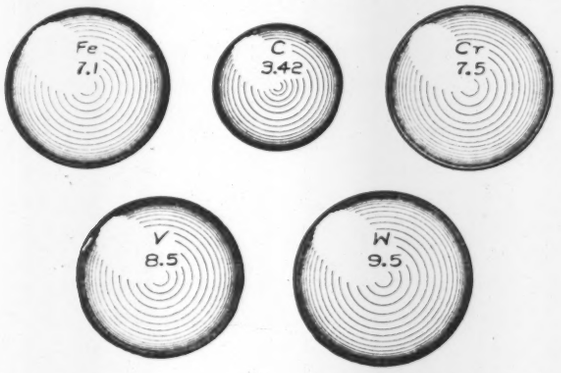


FIG. 12 RELATIVE SIZES OF THE ATOMS PRESENT IN HIGH-SPEED STEEL

carbon, tungsten, chromium, and vanadium is retained in supersaturated solution in fine-grained alpha iron. Such austenite as is retained on the quench is transformed into fine-grained alpha iron on reheating. On reheating or tempering, the complex tungsten carbide forms in critical dispersion at a temperature around 600 deg. cent., which, in conjunction with the retention of a fairly fine-grained structure, is responsible for the red-hardness of high-speed steel.

AN IRON-MOLYBDENUM ALLOY COMPARABLE IN HARDNESS TO HIGH-SPEED STEELS

The following statement made by Bradley Stoughton in his Metallurgy of Iron and Steel, page 403, fairly represents the state of the art with reference to the role of carbon in high-speed steel as well as other steel.

> It is commonly stated in the trade that tungsten will take the place of carbon in producing hardness, but this is not true. It is far more correct to say that tungsten will assist carbon in producing hardness, and therefore with high-tungsten steels we may have lower carbon. The distinction may appear merely academic, but it is well worth recognition by those who expect to make a study of these steels. No amount of tungsten or any other element will make steel hard in the absence of carbon, or even when the carbon is low.

Mr. W. P. Sykes, Cleveland Wire Works, Incandescent Lamp Department of the General Electric Company, has recently made a development which changes this art. If about 22 per cent of pure molybdenum is added to pure iron it is found that the molybdenum is soluble in the iron at a temperature of, say, 1400 deg. cent. On slow cooling a compound of iron and molybdenum separates out in relatively large particles, and the resulting alloy when cooled to room temperature is not very hard. The microstructure of this iron-molybdenum alloy after being slowly cooled is shown in Fig. 13.

When the alloy was quenched from the high temperature and solid solution preserved at room temperature, the Brinell hardness

FIG. 13 SHOWING MICROSTRUCTURE OF IRON-MOLYBDENUM ALLOY SLOWLY COOLED TO ROOM TEMPERATURE (SYKES)

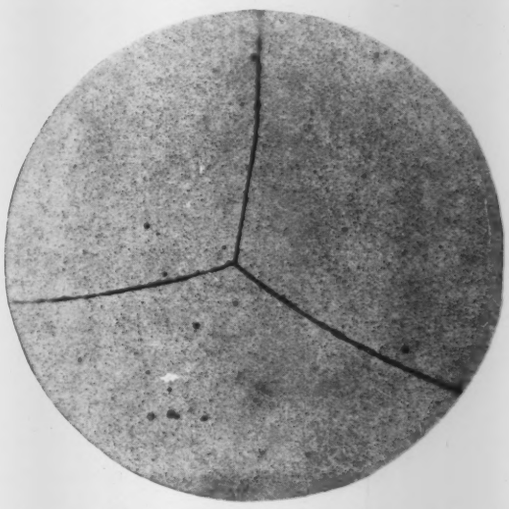


FIG. 14 SHOWING MICROSTRUCTURE OF IRON-MOLYBDENUM ALLOY OF FIG. 13 WHEN QUENCHED FROM THE HIGH TEMPERATURE AND SOLID SOLUTION PRESERVED AT ROOM TEMPERATURE (SYKES)
(Brinell hardness number in one instance, 214.)

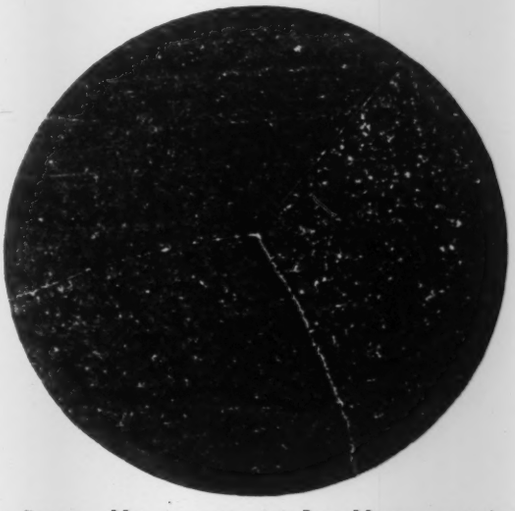


FIG. 15 SHOWING MICROSTRUCTURE OF IRON-MOLYBDENUM ALLOY OF FIG. 14 AFTER REHEATING TO 600–650 DEG. CENT. (SYKES)
(Brinell hardness number 531, comparable to that of hard steels.)

[11] Bain and Jeffries, *The Iron Age*, September 27, 1923, p. 805.

number in one instance was 214. This material is coarse-grained, as shown in Fig. 14.

Gamma iron plays no part in this system, the alloy retaining the body-centered cubic space lattice from room temperature up to the melting point. This quenched solid solution is supersaturated in molybdenum. On reheating to 600 to 650 deg. cent. it is possible for the molybdenum atoms to diffuse in the iron space lattice, and a portion of the molybdenum combines with some of the iron to form small (critically dispersed) particles of hard iron-molybdenum compound. Such an alloy heated for 60 hours at 600 deg. cent. showed a Brinell hardness of 531, which is comparable to that of the hard steels. Not only is the hardness comparable to that of hard steels, but certain dies made of this alloy operated at a high temperature showed up to 60 times the life of the best high-speed steel. The microstructure of the alloy in the hard state is shown in Fig. 15.

The significant thing about this alloy is that it contains no carbon and that its heat treatment is different from that of any other iron-base alloy but similar to that of the aluminum alloys described above. It will probably occur to you that the increase in hardness from 214 to 531 by precipitation of a portion of the molybdenum in the form of the compound is very great, whereas the increase in hardness in freshly formed carbon-steel martensite due to the precipitation of the carbide is very slight. The iron-molybdenum alloy is coarse-grained and the freshly formed martensite is fine-grained. The coarse-grained iron-molybdenum alloy contains 14 per cent of molybdenum atoms in solid solution and is relatively soft, whereas freshly formed carbon-steel martensite may contain only four per cent of carbon atoms and is glass-hard. This is another consideration in favor of the idea that the extremely small grains in freshly formed martensite are chiefly responsible for its great hardness.

Effect of Science on the Metal Industry

If time permitted it would be interesting to consider some of the other phases of the science of metals. Science has already had a tremendous effect on the metal industry and the future holds forth ever-increasing possibilities. At the present time a large number of men in the industry and connected with government bureaus, engineering schools, and private laboratories are well versed in metal science. Because new developments in the metal industry are becoming less apparent as the art progresses, it is practically certain that future developments and discoveries will be made in increasing proportions by those thoroughly acquainted with the science of metals.

Discoveries or new developments may have a profound effect on the metal industry as a whole. The direct saving in weight effected by the substitution of high-speed steel tools, for example, for carbon-steel tools would not be noticed in the total iron and steel production of the world. The use of high-speed steel, however, makes it possible to reduce the number of machine tools; the amount of floor space is proportionately decreased, resulting in decreased use of building materials. The effect of this reduction is to decrease the consumption of metal and other materials used in construction, and this is reflected in less freight tonnage, which in turn affects the number of freight cars, locomotives, rails, railroad accessory equipment, blast furnaces, mining machinery, etc. The indirect effect of high-speed steel has therefore been to greatly reduce the total tonnage of iron produced for a given service to the consumer. The same may be said of the use of alloy steels in place of carbon steels, and other examples are not difficult to find.

The conclusion to be derived from a study of the metal industry at the present time is that the industry is changing toward greater specialization of metals. This change is indicated by the more extended use of quality product as exemplified in the increasing proportion of alloy and heat-treated steel and an increase in the use of non-ferrous metals as compared to iron and steel. Consumers are being supplied with more and better product as time goes on, but less new metal is required for a given service to the consumer than at any time in history. The engineer is contributing to this result by better design and more intelligent use of metals. The scientist is contributing by providing a better understanding of the properties of metals, and by aiding in the improvement and development of processes and of metallic products.

It may seem that this trend is not in harmony with two changes in industry which are generally considered to be economically sound. These are mass production and standardization. I believe that specialization in the use of metals is not only consistent with the best economic practice, but that it is in harmony with the trend in mass production and standardization. The standardization movement is designed to unify practice as regards unnecessary multiplication of dimensions, sizes, types, compositions, etc. There is ample room for standardization in the metal industry, but it is not economically sound to discourage the production of materials with especially useful properties. We may look, therefore, in the future for the specialization in the use of metals to be continued and extended and for standardization to be applied in such manner as to facilitate rather than hamper this trend. What has been said previously about the increasing use of alloy and heat-treated steel and non-ferrous metals demonstrates the encouraging fact that many engineers now realize that it is sound economics to use quality material. He who manufactures the best metal products at reasonable costs should eventually be rewarded by becoming a mass producer. We should therefore look for mass production to prevail in the metal industry, but it must be *mass production of quality product.*

The Cracking of Boiler Plates

THE views which are at present held may be grouped roughly into two classes, viz., those which ascribe cracking to a form of corrosive (chemical or electrochemical) action, and those which seek the cause in severe local stress in the vicinity of the rivet holes, whether caused by undue concentration of working stresses or by the play of internal forces arising from the construction of the boiler. In America the view that boiler-plate cracking is due to the action of caustic soda in the boiler water prevails. It is suggested, but has never been conclusively proved, that at high temperatures and pressures, soda attacks steel and produces intercrystalline cracking—a feature highly characteristic of these boiler failures. It is said, furthermore, but convincing evidence has yet to be produced, that the presence of dissolved sulphates in the water entirely inhibits the deleterious action of soda. Experiments have, again, been made to show that a mild steel under stress can become embrittled by the absorption of hydrogen formed by electrolytic action in which the steel acts as anode. Such embrittlement cannot be denied, but—does it occur in boilers, even when caustic soda is present in the water? Moreover, steel thus embrittled breaks with a short fracture it is true; but not with an intercrystalline one. If, therefore, hydrogen embrittlement enters into the boiler phenomena at all, it is not the only important factor. Another view is that the intercrystalline cracking of mild steel in boiler seams is due mainly to the prolonged action of severe stresses set up in the steel by unduly heavy riveting pressures, by forcing together plates that do not fit properly, and similar causes. It is suggested on this view that the corrosive action of undesirable boiler water acts simply as an accelerating agent, just as corrosion is known to do in the so-called "season cracking" of brass and other alloys. The analogy with season cracking is, indeed, very strong on the ground that intercrystalline fracture, which is so very rare in metals and alloys, occurs in both cases. The diversity of views does not end at this point. The quality of the steel is also brought into the case, as it is pointed out that a steel which has been subjected to low-temperature annealing, so that it contains "balled up" cementite rather than well-distributed pearlite, is exceptionally liable to this type of failure. Then, again, it has been suggested that the cracks are, in reality, due to fatigue arising from the repeated "breathing" of the boiler as its temperature changes. This view, however, is difficult to accept, if only on the ground that the cracks are not in the least of the type which we know to result from fatigue; while, futhermore, the number of alternations which could occur from such causes is far too small to account for fatigue failure, except under excessively severe stresses. The subject is one that may become more important in the near future, and it is therefore the business of metallurgists and boilermakers to watch it with keenness in the hope of making a definite discovery of the cause, and hence of the cure. *The Engineer*, Nov. 20, 1925, p. 554.

Industrial Coöperation with the War Department

Addresses at Joint Meeting of Engineering Societies and the Army Ordnance Association by Secretaries Davis and MacNider, and Generals Harbord and Summerall—Transfer of Colors of 24th Engineers to Custody of the United Engineering Society

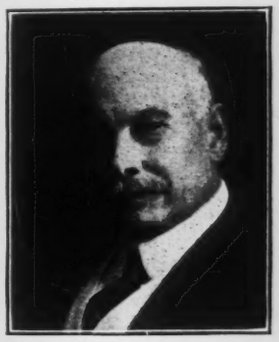
ON THE evening of Friday, December 4, one of the largest and most enthusiastic audiences that the Auditorium of the Engineering Societies Building has ever accommodated, gathered to testify by their presence to their hearty support of the War Department in its program of Industrial Preparedness as Insurance against War. The meeting, planned by the National Defense Division, A.S.M.E., was held under the auspices of the New York Sections of the four national engineering societies—the A.S.C.E., A.I.M.E., A.I.E.E., and A.S.M.E.—the American Chemical Society, the Society of Automotive Engineers, and the Army Ordnance Association. Col. Frank A. Scott being chairman of the committee on arrangements. Hon. Elbert H. Gary, chairman of the Advisory Board, New York Ordnance District, presided.

Prior to the addresses of the evening the impressive, bugle-punctuated ceremony of transferring the colors of the 24th Regiment of Engineers to the perpetual custody of the United Engineering Society took place, the presentation being made by Col. E. H. Whitlock and the colors being received by Wm. L. Saunders, President of the U.E.S.

A telegram of greetings from President Coolidge was then read by the chairman, the text of which appears elsewhere on the following page.

Col. F. A. Scott

Secy. D. F. Davis



Hon. E. H. Gary

In introducing the first speaker of the evening, Chairman Gary said that as peace-loving citizens those present had assembled to evince their interest in National Defense, so far as the dangers of possible unjustified wars necessitated, particularly certain phases with which industry was most concerned; and to renew their faith in the institutions which had made the nation great, and to express their confidence in the Government officials who were charged by law with keeping the nation secure against wanton attack.

Hon. Dwight F. Davis, Secretary of War, whom he was about to present, had entered the service of his country at the outbreak of the World War, serving successively as captain and major in the Missouri National Guard, later being promoted to lieutenant-colonel and serving as assistant chief of staff of the 35th Division of the Second Army in the American Expeditionary Forces. He had been twice cited in Divisional Orders for gallantry in action and had been eventually awarded a Distinguished Service Cross.

After being mustered out of service soon after the armistice, he had held several important positions by appointment of the President of the United States, among them that of Assistant Secretary of War, in which capacity he had been charged with the tremendous responsibility of mapping out the general policies under which the War Department was to proceed toward organizing the industries of the country for prompt production of munitions in emergency. That he had performed this work well, American science, engineering, and industry would be quick to testify.

Among his outstanding accomplishments as Assistant Secretary of War was the establishment of the Army Industrial College—an institution that bade fair to attain the high status in the field of industrial strategy that the War College occupied in military strategy.

Something over six months earlier, due to the illness of his superior, he had become Acting Secretary of War, and so well had he guided the War Department through the most difficult situations that the President of the United States had wisely appointed him Secretary of War, in which capacity he was present at the meeting.

At the conclusion of the applause which Judge Gary's tribute drew forth, Secretary Davis advanced to the speaker's desk and delivered the following address:

Address of Hon. Dwight F. Davis, Secretary of War

MOST PEOPLE think of the Army and the War Department as a great war machine. It is difficult for them to visualize the many constructive things the Army has done for the nation. Every American is familiar with the glorious history which has been the record of our fighting forces in defense of the Republic, and I am not detracting from that glorious record when I say that the greatest service the Army has rendered has been during the days of peace. The Army has been the defender of the Republic in time of war; it has been the pioneer of industrial development in times of peace.

Few people have any conception of the business activities of the War Department, and yet it is one of the largest business organizations in the country. The War Department has tried out and developed methods and devices which have been profitably adopted by commercial activities, and in many commercial developments it has been the pioneer.

The Manifold Business Activities of the War Department

Every one in this audience knows that American industrial leadership is due to our ability in mass production. Mass production has been made possible through standardization and interchangeability of parts in manufacture. Few of you know, however, that the first business organization in this country to introduce standardization and interchangeability of parts in manufacture was the United States Army. It did so in 1789 when the War Department gave Eli Whitney, the inventor of the cotton gin, an order for rifles, which were specified to be manufactured with interchangeable parts. The production of the modern automobile in such quantities and with such economy is based on the principle then established.

The Army has adhered to that pioneering principle. Many of the telephone and radio processes in use today were first developed by the Army Signal Corps. This Corps is now operating over four thousand miles of submarine cable. It also operates a radio system which links the national capital with the principal cities of the country and maintains several telegraph and telephone systems.

Today Army engineers are charged with the maintenance and improvement of our rivers and harbors, which is one of the most important business activities of the War Department. In this activity alone the War Department spent more than fifty-nine millions of dollars during the past year. Trade statistics have demonstrated that the commerce passing over the waterways maintained and improved under engineer supervision exceeds four hundred and forty million tons annually, and has a value of over nineteen billions of dollars. When we decided upon the development of Muscle Shoals, one of the largest power projects in the South,

Army engineers were given the job. Although this construction has not been completed, income is being derived from the power produced at Muscle Shoals.

The Panama Canal is one of the largest business enterprises in the world today and a monument to the constructive genius of American army engineers. Its administration and control are vested in the Secretary of War. This great waterway cost over 379 millions of dollars and has an annual operating expense in excess of eight million dollars. During the past fiscal year more than twenty-three million tons of freight were transported through the Canal, for which the United States collected tolls amounting to $21,400,000.

Another very important business enterprise of the War Department is the Inland Waterways Corporation, which is the pioneer in the revival of American inland-waterway commerce. This activity is operating a barge line on the Mississippi and contiguous rivers. During the first seven months of this year it carried 763,620 tons of freight and earned a net profit of over $230,000.

It was the Army Medical Corps which demonstrated to the business world ways and means of safeguarding the health of our citizens engaged in manufacturing occupations. The marvelous sanitary work in the Panama Canal Zone, Cuba, and our insular possessions is a monument to the skill, self-sacrifice, and loyal service of our Army doctors.

The Chemical Warfare Service is doing its part by developing gases which are being used most successfully in the fumigation of ships. It is experimenting with chemicals which it is hoped and expected will eventually exterminate the boll weevil and other destructive pests. Today American miners are protected from the deadly carbon monoxide gas by a chemical compound developed by the Chemical Warfare Service.

Our principal insular possessions are the Philippines and Porto Rico, and their administration has been intrusted to the Secretary of War. Before 1898 the trade between the United States and the Philippines and Porto Rico was practically zero. During the last year for which figures are available, the trade between the United States and these two colonial possessions totaled over 321 million dollars.

Handling the War Department mail is a big business enterprise in itself. The Adjutant General's office during the last year received, distributed, and disposed of over three million, nine hundred thousand pieces of mail. Our permanent files, covering the military records of the country since 1776, contain over two hundred million documents, indexed and available for immediate reference.

The War Department is not only a construction agency and an administration agency, but during the past five years it has been a great mercantile agency as well. At the conclusion of the World War the War Department had a vast amount of surplus property on hand, running from shoes and stockings to great real-estate holdings, from field-trunk lockers to automobiles, and from medical instruments to locomotives. Surplus property to the value of over four hundred million dollars has been transferred to other governmental departments, and over one billion dollars of surplus goods have been sold for cash to the public. By the advantageous sale of surplus property, the War Department has paid into the Treasury more than half of its current running expenses covering the past five years.

The Army's Pioneer Work in Commercial Aviation

The Army Air Service is doing pioneer work for commercial aviation by developing airways and perfecting safety devices for airplanes which are continually lessening the dangers of flying. American business is indebted to the Army Air Service for a new and profitable activity—aerial map making and aerial photography. Commercial-aviation companies have already entered this field. Pioneers in the development of trails for the covered wagons of days gone by; pioneers in the development of the roadbeds for the iron horses of the railroads; pioneers in the development of waterways for our commerce; the War Department is again pioneering in the development of the last element to be conquered by mankind, and "big business" methods were essential in all these pioneering efforts.

The business of the War Department is being conducted on a business basis. I have sketched certain activities which show that the War Department is in many respects analogous to a large business organization, and is performing like tasks in accordance with the best business principles and practices which industrial activities of the world have developed. The analogy does not end here. In fact, the business of the War Department carries it into close and permanent contact with the most diversified ramifications of American industry. I refer to our plans for the mobilization of the economic resources of the country, which are receiving such hearty support and coöperation on the part of industrialists as to insure that these plans shall be fundamentally business-like and sound.

The White House,
Washington, D. C.,
December 4, 1925

Hon. Elbert H. Gary,
71 Broadway,
New York, N. Y.

Will you please extend my greetings and best wishes to the men of affairs and action meeting tonight at the Engineering Societies Building in New York to honor Secretary of War Davis and Assistant Secretary MacNider. Industrial preparedness as an insurance against war, upon which topic they are to speak to you, is of the utmost importance. The more real insurance we have against conditions which might lead to war, the better for the country. Such gatherings as yours, where patriotic men of judgment and experience turn their attention toward practical methods of preserving peace, deserve the commendation and encouragement of all right-thinking citizens.

(Signed) CALVIN COOLIDGE.

Industrial Preparedness for National Defense

Preparedness for National Defense involves the effort of synchronizing the mobilization of men and munitions. Modern armies cannot be equipped as fast as they can be raised. This lesson was brought home to us forcibly during the World War. It was no less the bitter experience of our Allies. Winston Churchill says in his World Crisis, "There were no rifles, there were no guns. . . . We had nothing but staves to put in the eager hands of the men who thronged the recruiting stations." Many Russians were sent to battle with clubs, relying for their weapons upon the arms of their fallen comrades. Therefore, the saving of time in the swift and effective mobilization of industry is the essence of our plans. While Congress can appropriate men and money, it cannot appropriate time. As unfortunate as it may seem, the fact remains that money, material, and even soldiers lost can be replaced, but time once lost is gone forever. I need not emphasize the necessity for planning for the mobilization of industry further than to reiterate that planning means time saved.

At your session last year I discussed the details of the plan. Dealing as it does with the procurement of some 35,000 articles, made up of 700,000 component parts, comprising the output of over 20,000 factories, and involving the labors of millions of workmen, it is a huge task of industrial organization. If adequately planned in time of peace, as an engineer would plan his work in advance, it would mean the saving of months of time, thousands of soldiers' lives, billions of dollars. It may well mean the difference between defeat and victory.

Tonight I should like to call your attention to the broader aspects of this subject. Industrial Preparedness implies the mobilization of industry for military purposes during a national emergency. It involves the operation of adjusting peace-time energy and resources to meet the essential needs of national life and the maximum requirements of the military effort with a minimum disturbance of normal conditions.

Industrial Preparedness means that every man, woman, and child in the great Service of Supply throughout the land will be ready to do their part in National Defense; that demands of finance, power, labor, transportation, and materials have been intelligently analyzed and properly coördinated, that every dollar of the nation, every

resource of the mines, forests, farms, and factories will be marshaled against aggression to serve our boys in khaki.

We are not planning for war. We are planning against war and to guarantee an honorable peace, a righteous peace. Preparedness for self-defense is an inalienable right as old as the human race. Self-government and self-protection constitute the keystone of the arch of an enduring democracy. The combination of a weak and wealthy nation has never existed for any length of time in history. Like fire and floods, war is not a cause but an effect. Planning for national preparedness is therefore dictated by common sense and capitalizes the experience of the most tragic and yet the most important lessons of history. We should talk less about the horrors of war and do more to promote peace.

Our people are not militaristic. Service in the Army is but a temporary affair enjoyed by relatively few of our American citizens. The officer personnel, less than 12,000 in number, as I can assure you from intimate contact with them, are self-sacrificing, patriotic, and peace-loving. Neither the Army nor the Navy makes wars. Congress, the voice of the American people, declares wars, but the Army and the Navy are held responsible that these wars shall end victoriously. Each generation of peace-loving Americans has participated in a war of epochal results from 1776 to 1812, to 1860 and 1917. If present plans for preparedness against war can render America safe for peace for but one generation, they will accomplish more than any other plans in our history. They will fortify the peace movement voiced by every people in every land.

SECY. H. MACNIDER

MAJ.-GEN. C. P. SUMMERALL

GEN. J. G. HARBORD

American industrialists realize that while it is good business to avert chaos at the outbreak of an emergency, it is no less good business to avert chaos at the end of an emergency. Two pictures of industry stand out conspicuously in this planning. The one is the picture of industry as it operates in time of peace; the other is the picture as it looks in war. Industrial Preparedness has as its purpose the planning of the transition from one picture to the other with a minimum of dislocation and confusion both before and after war.

Then again, Industrial Preparedness is a form of protective insurance required in good business to protect American industry, American homes, and American firesides in the event of war. The economy resulting from a short, successful war is measured not only in time and money, but also in gold-star families.

The business man, therefore, considers his service in National Defense in time of peace as a small premium on this protective-insurance policy. Not only does the policy offer protection in the event of war but also it does much to guarantee the preservation of peace.

PROBLEMS INVOLVED IN PLANNING FOR PREPAREDNESS

Some of the general problems which form a part of the great business proposition with which we are dealing are raw materials, power, labor, transportation, and contracts.

Commodity committees of the office of the Assistant Secretary of War are studying materials in which shortage is likely to occur in emergency. Contact is established with industrial leaders, experts in governmental departments, trade associations and technical societies. There are fifteen active and thirty-eight inactive committees covering in all 180 commodities. This study is made with the purpose of collecting, collating, and evaluating data on requirements (Army, Navy, and civilian) and resources so that procurement control may be exercised in conservation, curtailment, priority, and allocations of materials, and on limiting requirements in new facilities to a minimum.

The Corps of Engineers has practically completed a power survey of the country and worked out plans for handling the power situation in an emergency. The National Electric Light Association, which comprises most of the power interests of the country, has given this active support.

The subject of the utilization of labor in war is one which is being intensively studied in the office of the Assistant Secretary of War with a view to benefiting by the experience in the World War of ourselves and foreign powers and adapting best principles, practices, and policies to the special economic conditions which may be met in the event of another great emergency.

We have a tentative plan drawn up for the control of railway transportation in a major war. The plan was formulated after discussion with officials of the Association of Railway Executives. The American Railway Association has appointed an official in each of the fourteen War Department Procurement Districts in order that coöperation may be secured between the Army and the railroads in solving local transportation problems.

The board of officers engaged in the preparation of war-time contract forms has been at work for over two years. Constructive criticism has been received from business men and manufacturers on proposed forms for purchase orders: the short-form contract, and the adjustable fixed-price contract. Another form is still under preparation—the adjusted-compensation contract for construction and manufactured articles. Probably a year or more will be required before all of these forms receive final approval.

I have given you a hasty review of a few of the general problems of this work. The Assistant Secretary of War, upon whom the responsibility of this work has fallen, will give you additional details. Planning work of such magnitude demands the assistance of the best business minds in the country. As Assistant Secretary of War, I received that wholehearted support. And I am confident that the same support will be given to our new Assistant Secretary, an able, hard-working, loyal public servant, Hanford MacNider.

The Chief of the New York Ordnance District, Colonel James L. Walsh, is doing splendid work in carrying on the plans. The dean of the American industrialists, Judge Gary, such leaders of industry as Mr. Gifford of the American Telephone and Telegraph Company, General Tripp of the Westinghouse Company, General Harbord of the Radio Corporation, and hundreds of others, are heartily coöperating. Members of the engineering societies, institutes, and associations, such men as Dr. Durand, Dr. Pupin, Mr. Norris, Mr. Reynders, and many others, have given most valuable advice and assistance.

CONCLUSION

In conclusion let me repeat: Industrial Preparedness is the contribution of business to the national peace. It is preparedness against war, not for war. Until war is forced upon us it is a paper plan, locked up in the national safe. It cannot conceivably be deemed militaristic, as under it no guns, no ammunition, no munitions of any kind are made. But if war comes, it will be a potent factor in winning peace through victory. It is insurance against war, assurance of peace.

The motto of Industrial Preparedness appeals to every American: "If war is forced upon us, there must be no slackers and no profiteers." Equality of obligation, mutuality of responsibility, the common defense of all by all, is the democratic doctrine for a free republic. This is the spirit of Industrial Preparedness; it is the spirit of America.

Addresses by Secretary MacNider and Generals Harbord and Summerall

IN INTRODUCING the next speaker, Hon. Hanford MacNider, the newly appointed Assistant Secretary of War and successor to Secretary Davis, Chairman Gary stated that soon after the outbreak of the war, Secretary MacNider had been commissioned a captain and assigned to the Ninth Infantry of the regular army, later being promoted to major and to lieutenant-colonel, and had been awarded the Distinguished Service Cross for extraordinary heroism in action in France.

In the course of his remarks, Secretary MacNider said that the last war had proved that man power was available for every need. Four million men could be sworn in as fast as they could raise their right hands. It was not his intention to minimize the problem of mobilization and training, but the war had also demonstrated that there must be seventeen men backing every combat soldier up with matériel if he was to be effective at the front.

The office of The Assistant Secretary of War was charged with the current procurement of the army—a plain every-day business problem, circumscribed, however, by many laws and necessary regulations. Secretary Davis, in that capacity, had given it his earnest study, and evolved policies and supervised their enactment. He had called in experts and business executives to study the procedure and make constructive suggestions, and an intense and searching examination had brought forth many helpful and clarifying additions.

This plan was now being carried down into every one of the seven services of supply. There was a still broader plan under way —a War Department Business Council—made up of outstanding experts in those sections of the business world most closely allied with our current-supply problem—to study present policies and administration and to assure the people from their findings that the War Department's attempt was to serve the nation in a business-like manner. Every one of the seven supply chiefs—Ordnance, Quartermaster, Signal, Air, Engineers, Medical, and Chemical Warfare—had welcomed this plan with open arms.

Of necessity the present supply organization had to be so built that like a rubber band it could in a moment be stretched to a hundred times its present size without breaking under the strain. It must be just as effective in its new shape as in the old, it must carry a heavier load at every point. It must be kept alive in times of peace that it might not succumb to dry rot.

The nation's best insurance against war was not a great army but an expert nucleus, not great gatherings of war matériel to fret it in peace, not great mobilizations of men or arms, but rather a well-conceived, all-inclusive, and expert structure of emergency-insurance plans. When the people through the Congress declared them operative, the nation could unite into one mighty and overwhelming company—one which could meet and put out any conflagration menacing the peace and welfare of the world.

At the conclusion of Secretary MacNider's address, Chairman Gary introduced Gen. James G. Harbord, Chief of Staff of the A.E.F. during the World War, Commanding General of the Second Division, and later Commanding General of the entire Service of Supply.

General Harbord, now engaged in business and president of the Radio Corporation of America, called attention to the fact that the two men heading our great War Department were each entitled to wear the Distinguished Service Cross granted only for "most extraordinary heroism in action." He doubted if there was another important governmental department in the world headed by two men with such a record.

The problem of industrial preparedness, he said, could not be divorced from the remainder of the National Defense. There must be a balanced defense, for trained men without munitions and munitions without trained men were equally helpless. Five years ago Congress had approached the problem of National Defense with great patriotism and intelligence, and worked out the best scheme for it that our country has ever had. It had included provision for both man power and the machinery for enlisting the country's great industrialists in the mobilization of business. Five years had gone and the people were fast forgetting their interest in the last war and the possibility of the next one.

Aside from the particular field of Industrial Preparedness, he felt that it was the duty of business men to uphold the Secretary of War in his efforts to get suitable appropriations for the military establishment, for unless industry interested itself in the whole problem of National Defense, all the excellent work it might do on its own particular phase of industrial mobilization would be to a large extent wasted effort.

If what was now being done in the way of preliminary allocation and negotiations had been done prior to the outbreak of the World War, our participation in it would have been appreciably shortened; our losses in killed and wounded would have been diminished; and our expenditures now being paid for in taxes would have been decreased by one million dollars for every hour by which we had shortened the duration of that conflict.

Maj.-Gen. Charles P. Summerall, Commander of the Second Corps Area, U.S.A., whose brilliant military career was fittingly epitomized by Chairman Gary in his introduction, was the last speaker of the evening. General Summerall said that in the name of the Army he wished to acknowledge all that industry was doing for the welfare of the military establishment and of the country. On behalf of that establishment he wanted to say that it was heartened and encouraged beyond measure to know that at last it was not an isolated element of the people, looked upon as a body of men who wanted to involve the country in war, but that its members were a part of that great citizenship who stood, as Secretary Davis had so eloquently pointed out, for the well-being of our land in peace, and as a part of the guarantee of the nation against a day when, if unhappily it might be, the agency of peace again should fail.

Prior to the meeting Judge Gary entertained a distinguished company of engineers, industrialists, and bankers at dinner at the University Club in honor of the speakers of the evening.

FOR years, trade associations have been faced with doubts about the statistical activities in which they could lawfully engage. The members of many associations had come to fear that statistics of any kind were, in the opinion of the Government, inherently wrongful, when they related to economic activity, although in every other walk of life statistics were held in high esteem. In this situation, the Supreme Court itself has granted relief. It has handed down opinion in two cases brought by the Department of Justice against trade associations, holding that their statistical activities were lawful. Thus, these opinions serve to indicate for all trade associations that there is no violation of the federal anti-trust laws if they gather and distribute the essential business facts that the Supreme Court described.

With the clearer understanding of this liberty under the law (which remains unchanged), there is no bar to the development and proper use of business statistics. This clearing of the atmosphere should mark the passing of guessing as to the facts concerning our commodity production and distribution, provided there is a willingness, at the source, to supply the information.

With these rulings as a basis, trade associations will undoubtedly appreciate the opportunity of rendering to their constituency a valuable service by providing means for gathering and reporting statistics dealing with such important trade information as producing capacity, orders, shipments, stocks and markets, as shown by prices on closed transactions. In the renewing of statistical activities, it is timely to suggest simplification of methods and forms in order that the information which is found be obtained and presented as quickly and accurately as possible at the minimum of expense. Such uniformity will enable the transmission of information gathered in the form of charts or graphs, when desired, much less cumbersome than presenting great masses of figures. If uniformity of method is observed, it will greatly simplify the matter of not only charting a given line, but also including such other lines as may be important in comparing the trends of the industry.

Considering the present state of business and the dearth of such information as an aid to intelligent individual control in industry, it is expected that a large number of associations will avail themselves of this opportunity to participate in a coöperative study of ways and means whereby statistics may best be developed and handled. (*Machinery*, December, 1925, p. 314.)

The German Museum in Munich

By DR. OSKAR VON MILLER,[1] MUNICH, GERMANY

THE German Museum in Munich shows the development of the various branches of natural science and technology by means of original apparatus and machines, as well as by means of models and arrangements for demonstration, in a manner easily understood by all classes of people. Its purpose is to instruct students, workers, etc. as to the effects of the multifarious applications of science and technology to the problem of human existence, to stimulate further progress, and to keep alive in the whole people a respect for great investigators and inventors and their achievements in natural science and technology.

That all this is possible is shown by the attendance at the Museum since its opening in May of this year, for in a city of about 600,000 inhabitants the collections have been visited by about 6000 on each week day and by about 12,000 on Sundays and holidays.

The German Museum is not a municipal or state institution but an independent enterprise, having its own regulations, its own administration, and its own financial resources, and is virtually free from government influences.

The Honorary Presidents (ex-officio) of the German Museum are the German Chancellor, the Bavarian Prime Minister, and the German and Bavarian Ministers within whose sphere of action the institution comes.

The administration is in the hands of a Board consisting of three members who are elected by the Advisory Council by simple majority vote.

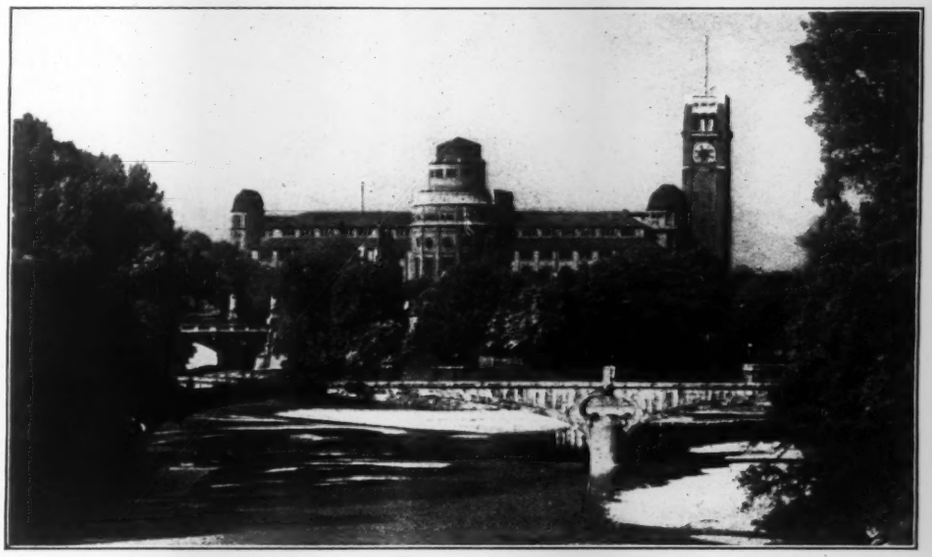


FIG. 1 THE NEW GERMAN MUSEUM BUILDING IN MUNICH

Since the foundation of the German Museum the Board has consisted of the author, who is its chairman, Dr. von Dyck, Rector of the Munich Technical Institute, and, until a few years ago, Dr. C. von Linde, the pioneer investigator in the field of refrigeration. After Dr. Linde retired, he was succeeded by Dr. Kerschensteiner whose work in teaching is well and favorably known in America.

The Board conducts the affairs of the Museum and is specially responsible for the building, for the arrangement of the collections, and for the management of the Museum. It is assisted by an Advisory Council consisting of 100 members, including permanent representatives of the Commonwealth, of the administration in power, and of scientific and technical associations, as well as a number of distinguished elected members.

Among those who have served as Chairmen of the Board have been Wilhelm von Siemens, W. C. Röntgen, Hermann Blohm, Carl Duisberg, Krupp von Bohlen, His Excellency von Harnack, and Count Zeppelin.

For the assistance of the Board and the Advisory Council there is at present a committee of some 600 members composed of specially prominent and influential persons representing all the branches of natural science and technology covered by the Museum. The importance of this committee does not reside in its collective activities but especially in the fact that the individual members are consulted in important special questions, such as the discovery and procurement of certain exhibits for the Museum, the development of important demonstration equipment, etc.

The Museum includes a construction bureau comprising about 15 employees, a scientific-technical bureau comprising 49 persons, as well as 60 museum attendants, comprising mostly mechanicians, laboratory assistants, miners, etc.

The plan for the foundation of the German Museum was submitted on May 5, 1903, by the author to a small, select group of men, and met with such immediate approval at their hands that on June 28 of the same year the Museum was established under the patronage of the then Prince Ludwig of Bavaria.

The collections, which rapidly accumulated, were temporarily housed in the old National Museum and in the Isar Barracks, where about 140,000 sq. ft. of floor space was available, and were opened to the public for the first time on November 13, 1906.

On the same day the ceremony of laying the cornerstone of the new Museum building took place, the plans prepared by Prof. Gabriel von Siedl being already completed.

In spite of the extremely difficult conditions caused by the war and the subsequent period of inflation, it has been possible to complete the new Museum building, Fig. 1, on an island in the River Isar provided by the municipality of Munich, thanks to the very general, self-sacrificing, and unremitting support received.

The new building was opened on May 7, 1925, on the 70th birthday of its founder, and the unusually extensive festivities celebrating the event were participated in not only by all of the people of Munich, but also by the heads of the German Government and the German Federated States, representatives of allied academies, polytechnic institutes, and museums, and by representatives of numerous non-German scientific and technical associations; and it was a special pleasure for the guests numbering thousands to witness the representative of the A.S.M.E. offering the felicitations of American engineers.

The Museum building at present has altogether about 430,000 sq. ft. of floor space, partly in rooms and partly in halls, for the reception of exhibits, and an idea of the extent of the collections may be gained from the fact that the route one has to travel to pass by the various exhibits is over nine miles in length and takes four hours to cover without pausing to inspect the exhibits.

Although the collections of the Museum are limited to the branches of the exact natural sciences and those branches of technology which are specially aided by scientific research, there are nevertheless more than 60 groups represented in its six main divisions.

The first of these main divisions comprises Geology, as well as Mining and Metallurgy, in which replicas of ore, coal, and salt mines true to nature are shown.

Each group is introduced by an ensemble plan clearly showing the various branches exhibited therein, as may be seen from Fig. 2 for the group Mining.

In all the groups of the German Museum not only is the present status of science and technology illustrated, but also their development from the most ancient times to the present, and the sole criterion employed in the selection of exhibits has been that they shall represent an important stage of development.

[1] Civil Engineer. Hon. Mem. A.S.M.E.

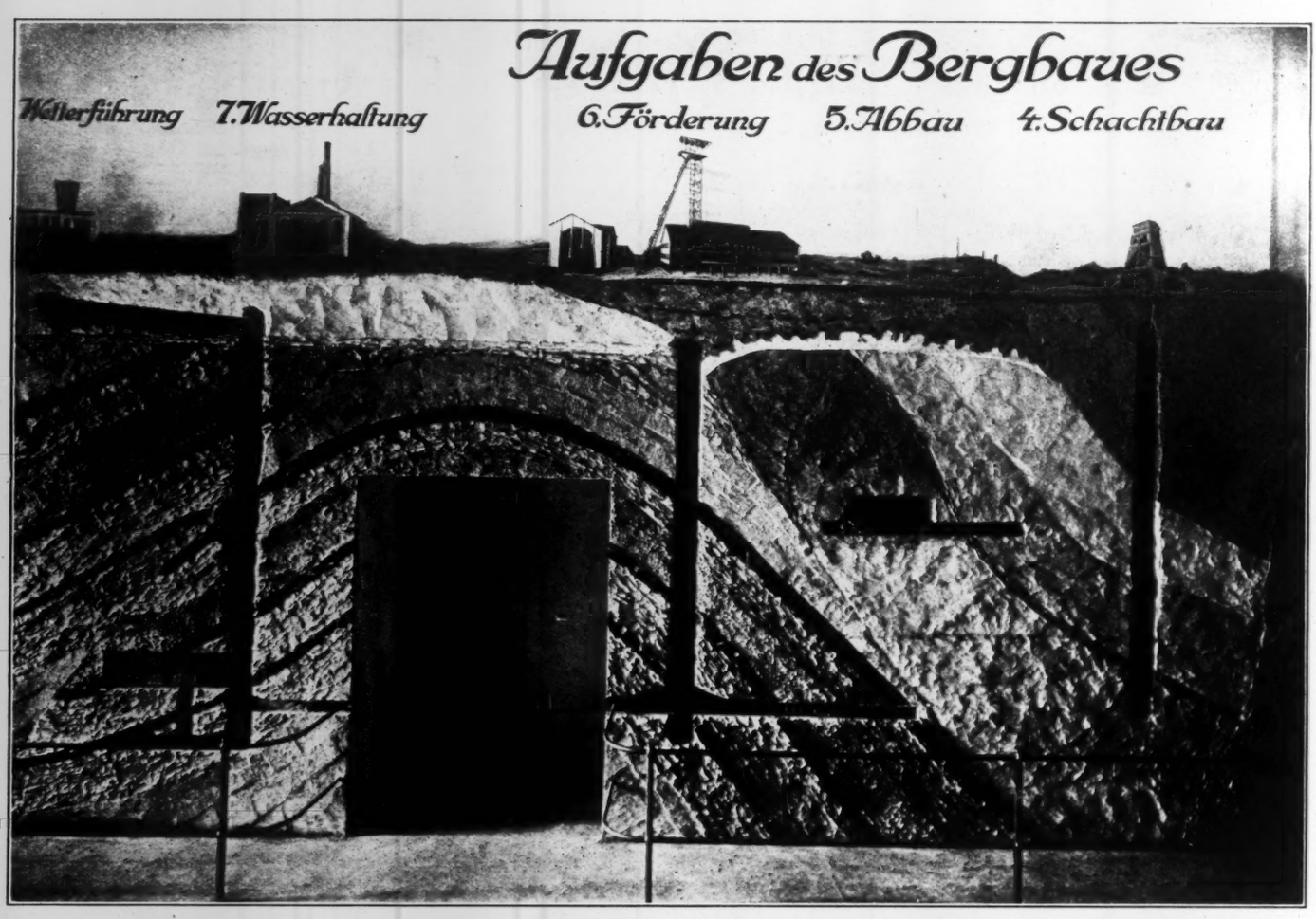


FIG. 2 SECTION FROM ENSEMBLE PLAN FOR THE GROUP "MINING," IN WHICH THE VARIOUS PROBLEMS IN MINING ARE EXPLAINED IN A LARGE RELIEF

FIG. 3 DRAIN PUMP WITH TREADWHEEL-OPERATED BUCKET CHAIN FROM A MINE OF THE TIME OF AGRICOLA

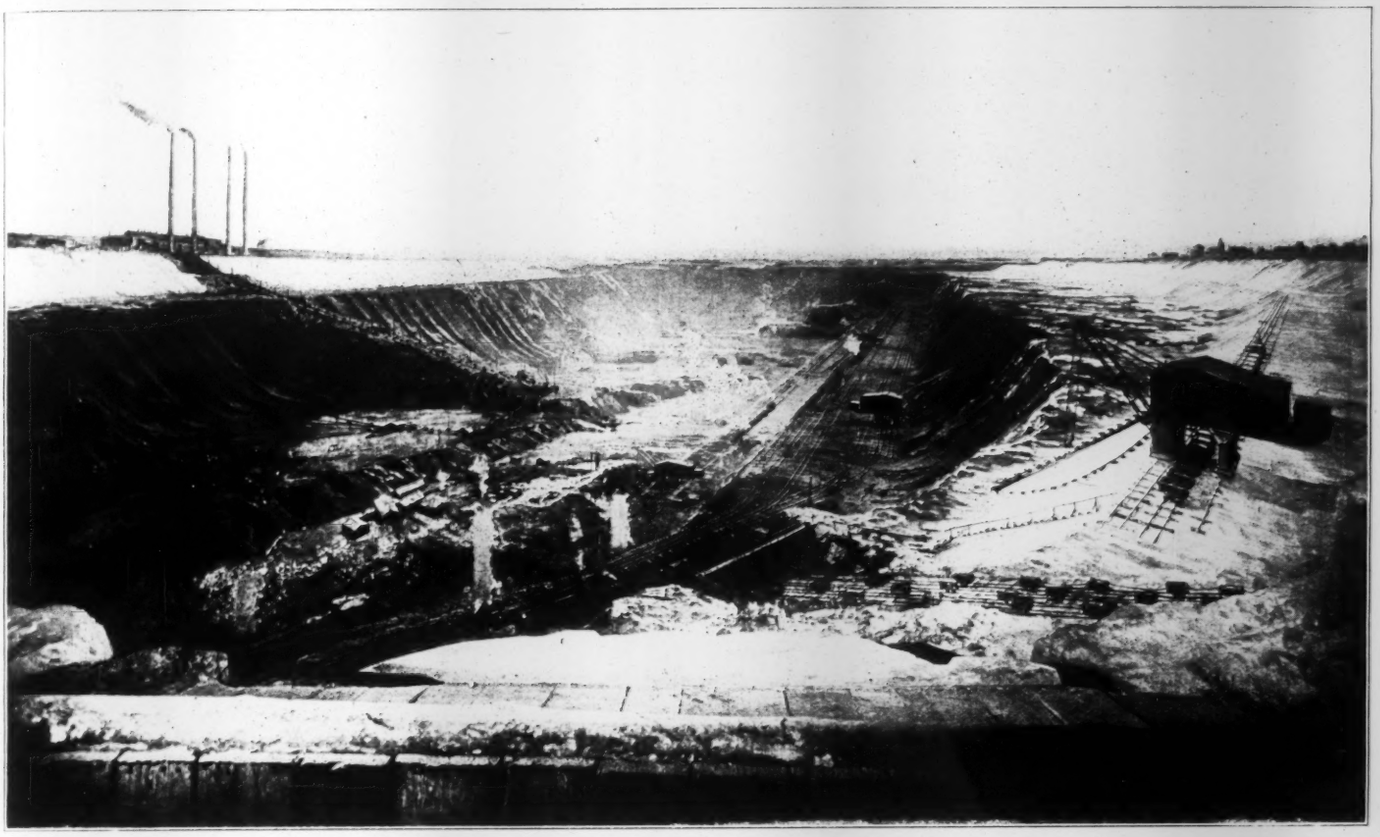


FIG. 4 VIEW SHOWING THE OPEN-PIT MINING OF LIGNITE IN CENTRAL GERMANY (PAINTED BY PROF. ZENO DIEMER)

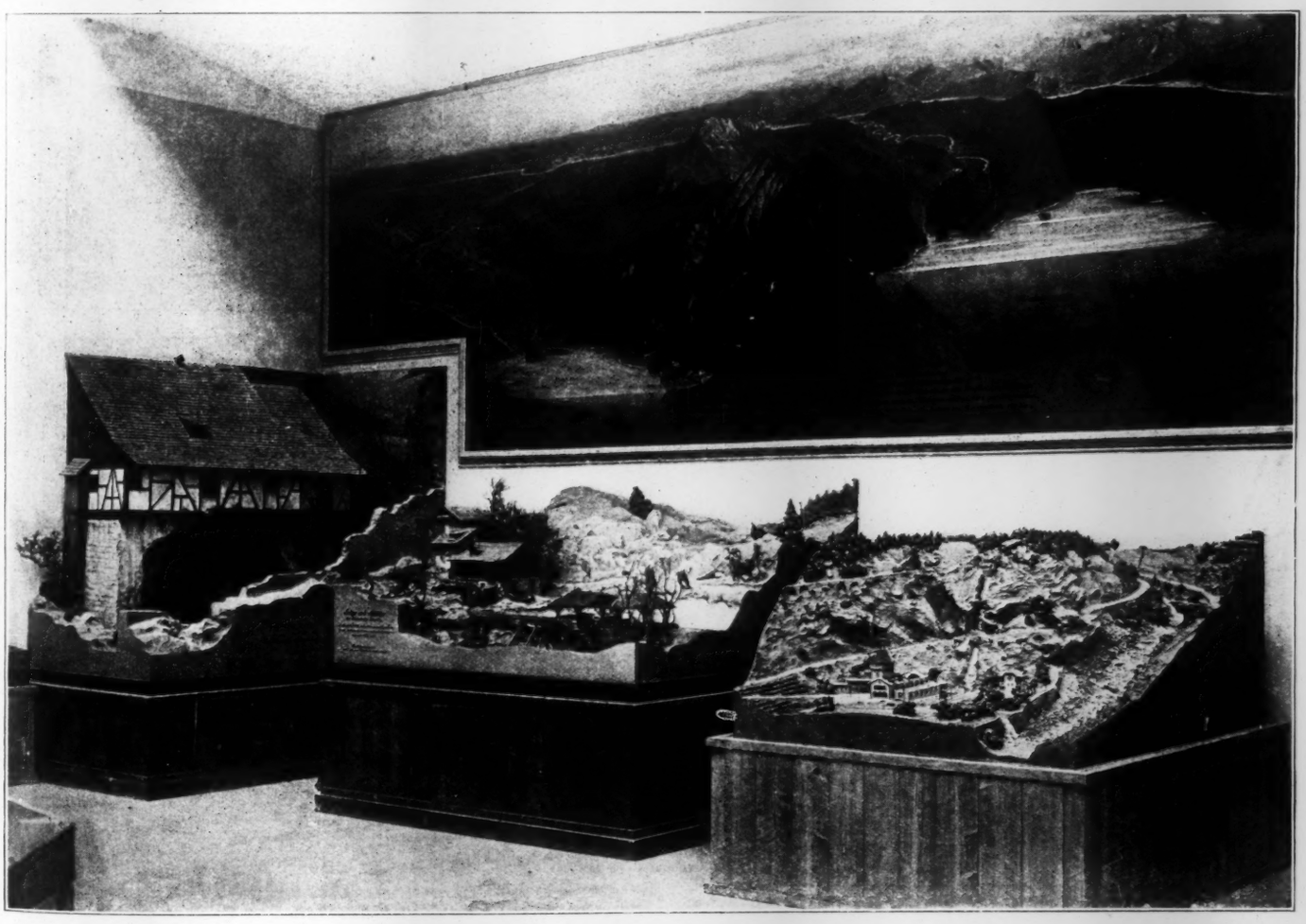


FIG. 5 VIEW OF DIVISION OF HYDRAULIC MACHINERY, SHOWING OLD WATER WHEELS AND A SECTIONAL PAINTING OF THE LAKE WALCHEN HYDROELECTRIC DEVELOPMENT

FIG. 6 REPLICA OF WATT'S STEAM ENGINE WITH BOILER OF THE YEAR 1788

In connection with the mining group smelting methods with blast furnaces, bessemer converters, Siemens-Martin plants, etc. are shown. Then follows the development of prime movers from the primitive treadmills of the Middle Ages up to the windmills, water wheels, turbines and steam engines of the present. To elucidate this group a full-size working model of Watt's engine, the first Sulzer engine, a steam turbine in section, etc. are shown. Near by the development of the gas engine and Diesel engine—which mainly took place in Germany—is illustrated by exhibits of the original engines.

Considerable space is devoted to transportation, wherein are shown not only the oldest devices for conveying loads and persons—the Roman war chariots, the sedan chairs of the Middle Ages, etc.—but also a complete presentation of the development of the locomotive, including an excellent replica of the English "Puffing Billy" in working order, the first electric locomotive built by Werner Siemens, etc., as well as the development of railway cars, including a very fine model of the first Pullman car.

Close by are representations of highways, railroad tracks, bridges, and waterways, among which original parts of Brooklyn Bridge in New York and a specially fine model of the Panama Canal; and views of New York Harbor remind us specially of the progress made in America.

A large part of the group Transportation is devoted to the division of shipbuilding, the development of which is shown from the ancient ships of the Phoenicians, Roman galleys, viking ships, the caravel of Christopher Columbus, old English battleships, and the celebrated ships of the Hansa towns, down to the huge vessels of the present time. Among the latter represented is the battleship *Rheinland*, the model of which is so arranged that by removing its sides the machinery and interior equipment are exposed to view.

The group Aeronautics not only contains Lilienthal's flying machine, the first machine for that purpose ever built, but also one of the first Wright biplanes, and presents in orderly sequence the whole development of lighter-than-air craft up to the most recent all-metal planes of Junkers, Dornier, etc.

Among the airships shown are the first dirigible Zeppelins and the airships of Gross and Parseval—historical masterpieces of the first rank.

The groups Physics and Chemistry, in addition to original

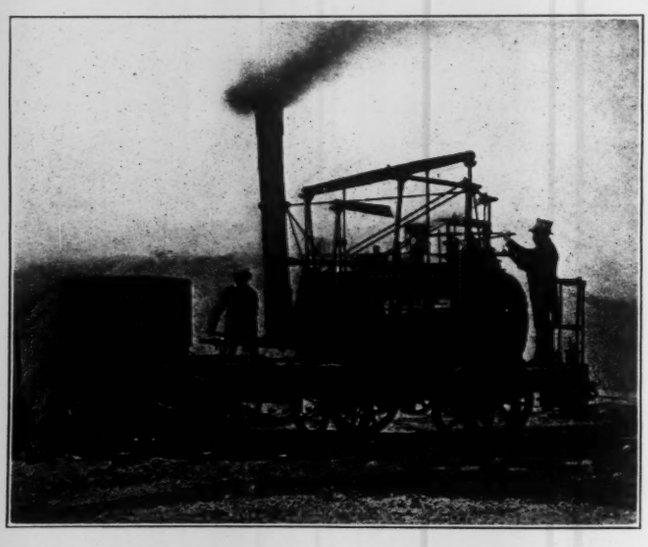


FIG. 7 FULL-SIZE WORKING MODEL OF "PUFFING BILLY" DURING DEMONSTRATION IN THE COURTYARD OF THE GERMAN MUSEUM, MARCH 21, 1924

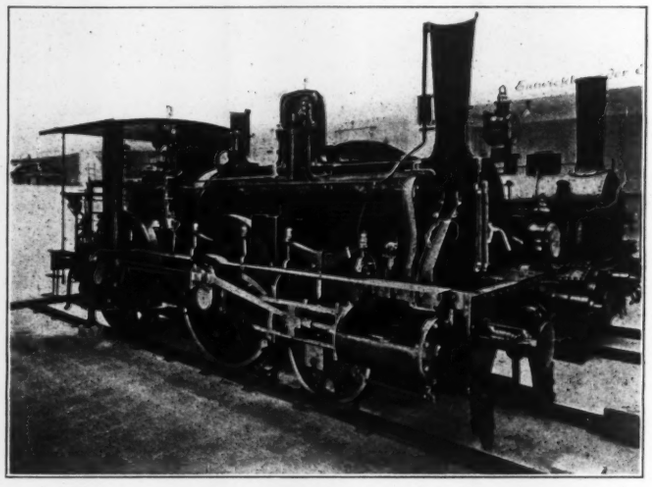


FIG. 8 ORIGINAL OF AN EXPRESS-TRAIN LOCOMOTIVE WITH ALL PARTS IN SECTION AND MOVABLE TO SHOW OPERATION

FIG. 9 ORIGINAL OF THE FIRST GLIDER MADE BY OTTO LILIENTHAL

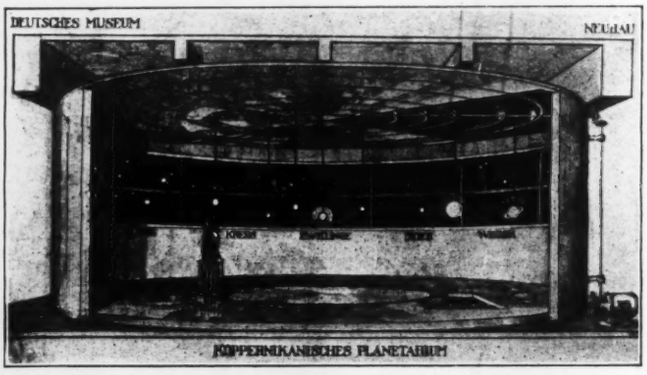


FIG. 10 THE COPERNICAN PLANETARIUM

apparatus used by the most prominent investigators, also contain equipments for demonstration which are intended to facilitate proper appreciation by visitors of scientific achievements and to interest them in the progress of natural sciences and technology. The apparatus for demonstration are placed side by side with the original apparatus so that visitors may carry out the necessary experiments themselves.

Among the more notable sets of original apparatus in these groups may be mentioned the original air pumps and hemispheres of Otto von Guericke; the optical apparatus of Frauenhofer, Helmholtz, Kirchhoff, Bunsen, and others; the original apparatus employed by Robert Mayr, Joule, Linde, etc.; the first telephones of Reis and Bell; Edison's phonographs; original apparatus of Ohm, Steinheil, Gauss, Weber, etc.; the original experimental Hertzian wave apparatus; the first Röntgen tubes, etc.

Among the demonstration apparatus which have become known best are the two planetariums constructed by the Zeiss Company and embodying the ideas of the president of the Museum.

The first planetarium, built on the theory of the Greek philosopher Ptolemy, consists of a sphere 8 meters (26.2 ft.) in diameter representing the heavens, in the dark interior of which the spectators are admitted. In order to facilitate orientation, the horizon is located level with the eyes.

By means of a rotating projecting apparatus placed in the center, luminous figures of the fixed stars are projected on to the dark heavens in their apparent movement round the earth, and by special apparatus the apparent movement of the sun, moon, and planets, thus enabling any one to reproduce the movements corresponding to a year or a day in greater or less time. The planetarium shows with special characteristics the rising and setting of the sun, the moon, the partly retrograde motions of planets, etc.

A second (Copernican) planetarium just as large shows the actual movement of the stars. Here the sun and fixed stars are fixed, the earth and planets moving in the ecliptic around the sun. Below the earth a moving platform is provided, on which the spectators stand in order to participate in the movement of the earth through space, and so that they may from a proper conception of the actual position of the stars among themselves and as against the earth at any time of day or season.

FIG. 12 LIFE-SIZE REPLICA OF AN ALCHEMIST'S LABORATORY

In the field of Astronomy, astronomical instruments and models of entire observatories, including a model of a turret equatorial telescope, etc., are shown; three large observatories of different periods enable the visitors to make observations on the heavenly bodies themselves.

The fourth main division of the Museum comprises the paper and textile industries and agriculture; the textile-machinery division including numerous English inventions, and the agricultural division important American productions, for example, the McCormick mowing machines, etc.

The last of the five main divisions is now in course of installation, namely, the dwelling-construction and town-building group, with its divisions of gas, water supply, electricity works, etc.

Here also are represented American masterpieces which were secured by the author on his visit to America in 1912; one of these, however, the model of the Woolworth Building, has not yet arrived in Munich.

At the center of the collections described above is a Hall of Fame containing portraits and busts of the most eminent German scientists and technicians with inscriptions referring briefly to their achievements, the purpose of which is to perpetuate the memory of the greatest masters of German science and technology in the minds of the people.

Among these may be mentioned the life-size portraits of Otto von Guericke, Leibnitz, Fraunhofer, and Gauss, the reliefs of Werner Siemens and Alfred Krupp, the hermae of Robert Mayr and Helmholtz, the bronze tablets of Otto Lilienthal, Count Zeppelin, etc.

The portraits of non-German investigators and engineers such as Faraday, Watt, Lavoisier, Ampère, Berzelius, Franklin, Galileo, etc., are suitably disposed in the divisions in which are exhibited the apparatus devised by them.

The Museum has still to be completed by a library building. In this visitors should find all books treating of natural science and technology, and especially of their history, to supplement the studies they have made of the collections in the Museum.

In addition to this extensive collection of books there will be a collection of designs and plans to give students, mechanics, and workmen an opportunity of finding standards covering any problem they may be working on, which they may not only study but also copy.

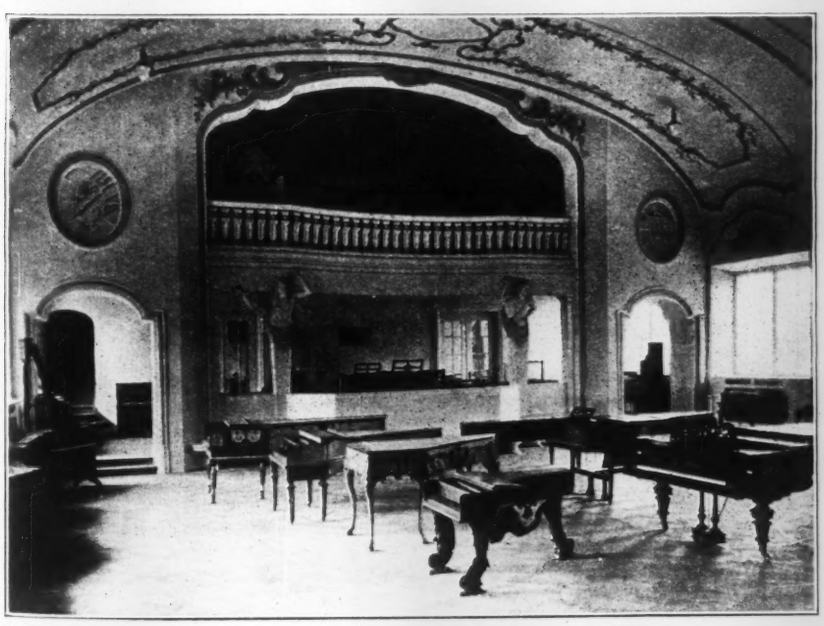


FIG. 11 VIEW OF MUSIC DIVISION, IN WHICH THE OLD SPINETS, CLAVICHORDS, ETC., ARE PLAYED

Furthermore, the library building will have spacious halls provided with the most modern equipment in which lectures may be delivered with the aid of models and Museum exhibits to large audiences and in this way contribute to a more profound appreciation of science and technology.

Only a part of the money for building the German Museum, for arranging the collections, and for operation has been provided by the German Government, by Bavaria, and by the city of Munich. Most of it has come from funds contributed by the German people at large, and in this way the Museum has become an enterprise which has united a multitude of citizens in the pursuance of a common aim.

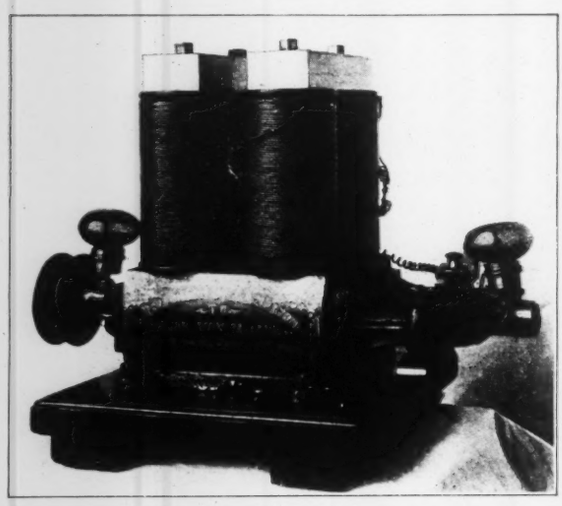


FIG. 13 FIRST SMALL ELECTRIC MOTOR BUILT BY EDISON, WITH THE INSCRIPTION, "PRESENTED BY T. A. EDISON TO OSCAR VON MILLER, NEW YORK, JULY 25, 1883"

Although the building of the Museum has in this way brought together scientists, engineers, workers, etc., visiting the exhibits will be more effective in this respect, for visitors will see that all classes of people take part in the achievements of modern life. Workmen will see what laborious mental work was necessary by the greatest investigators in order to lay the foundations of technology, and how great has been the ability of those who, starting with simple workshops, have created the industries. Members of the privileged classes will learn in the German Museum how toilsome and difficult is the work of laborers, for instance, in the mines, and what great skill mechanics must have in order to make the instruments, apparatus and machines which engineers have invented and designed. The German Museum will waken in them the feeling that the workers not only are entitled to wages but also to respect, and through this there will come about a more intimate sense of partnership between all working classes. Moreover nations also will be drawn together, for the Museum shows that achievements in science and technology are not due to any one people, but that all peoples have contributed to bring them about.

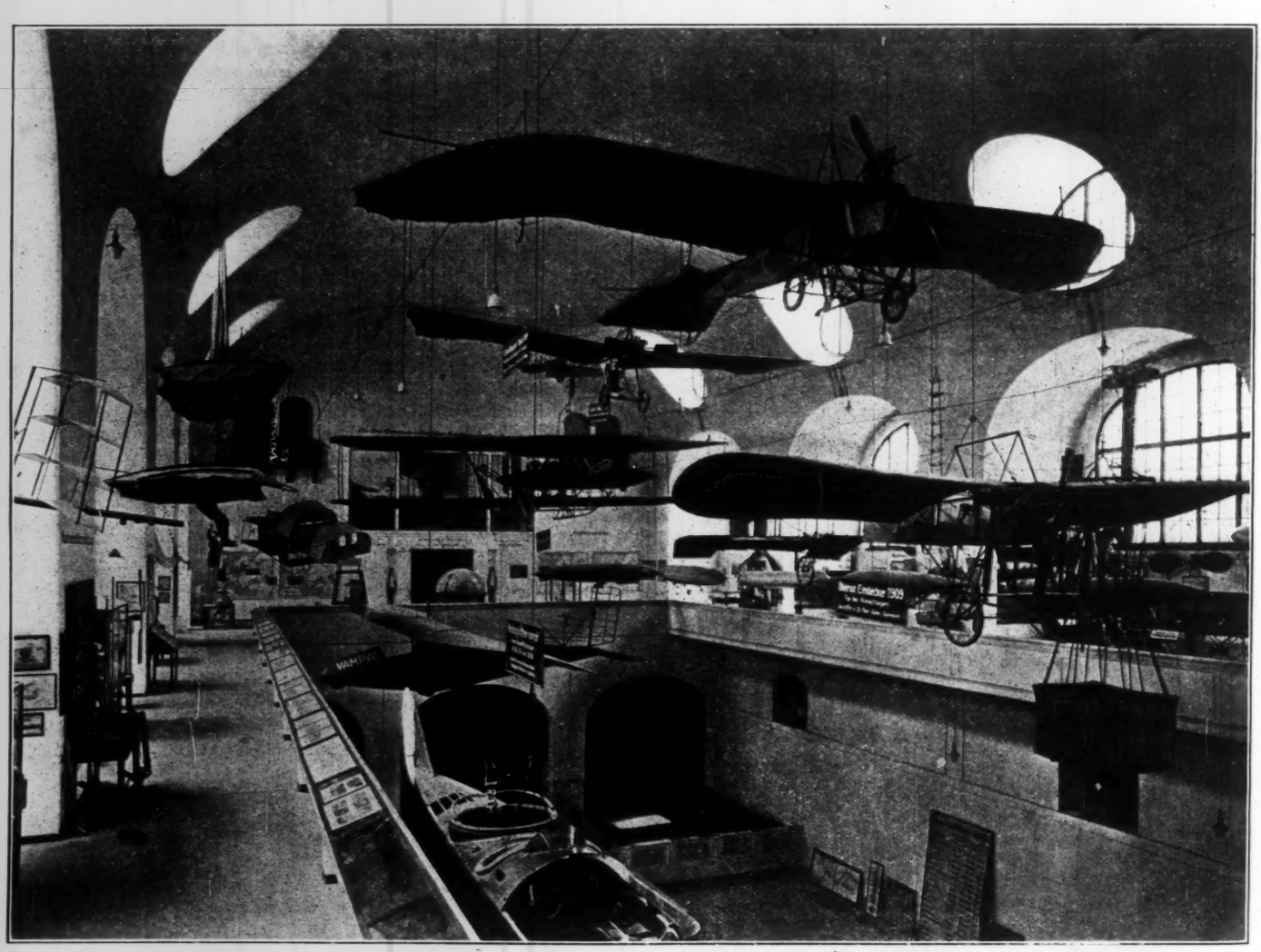


FIG. 14 VIEW OF AERONAUTICAL DIVISION

Normal Pitch the Index of Gear Performance

By G. M. EATON,[1] EAST PITTSBURGH, PA.

The paper brings out certain departures from previously accepted practice which are useful in the manufacture of heavy involute gearing, as they ease the performance during the breaking-in stage of operation. It shows that material improvement in performance may be secured by adopting the proper relation between the normal pitches of the driving and driven gears, measured at the point of tooth engagement. Finally, it outlines the development of normal-pitch indicators.

THE methods outlined here apply particularly to gears in heavy duty, as, for example, in heavy-traction electric locomotives. The fundamental principles, however, apply to any involute gearing.

The aim throughout has been the establishment of the widest limits that will insure acceptable performance. This is being approached by exploration of the effects of various departures from precise accuracy.

Quiet gearing may be defined as gearing which operates with an acceptable degree of vibration and noise. Thus it is possible that gearing which is quiet in one service may be regarded as prohibitive under more drastic requirements.

Variables

Quiet operation can be assured only by holding a large number of variables within proper limits. These variables group themselves naturally into two main classifications:

a Variables in the gear mounting
b Variables in the gear proper.

All the variables in the gear mounting, as, for example, the accuracy of alignment in both planes, the adequacy of bearings, the rigidity of structure, lubrication, critical response to existing cyclic disturbance, and other well-recognized fundamental characteristics, must be held within limits adapted to the degree of quietness that is demanded.

The major gear variables upon which quietness depends are:

a Initial engagement of mating teeth (premature, correct, or delayed) as determined by normal pitch. (This is the only one of the fundamentals analyzed in this paper.)
b Concentricity
c Contour
d Smoothness of working surfaces.

In setting the limits of normal pitch within which the inspector may accept gears, the main fundamentals which the engineer must analyze are:

a Angular velocity
b Inertia of associated rotating parts
c Elasticity of associated rotating and stationary parts
d Normal tooth pressure
e Lubrication
f External disturbances of cyclic characteristic
g Amplifying tendency of associated structures.

The engineer must also analyze the combination of the first four items of his list as to its tendency toward producing critical response to each of the existing cyclic disturbances. The degree to which the engineer must pursue the more intricate of these investigations is a direct function of the measure of perfection which he is trying to achieve.

The order of importance of the various items may be different for various installations, with the single exception that the character of the initial engagement of mating teeth is probably always the prime function of quiet operation.

Service Conditions

The discussion is based upon the main gears of electric locomotives recently supplied to the Norfolk & Western Railroad Company by the Westinghouse Electric & Manufacturing Company and the American Locomotive Works. There was a demand that vibration be held within limits that were in keeping with the endurance of associated structures.

Fig. 1 shows the main motor with its overhung pinions, outside of which are mounted collector rings for three-phase current. These collectors and their associated leads formed the limiting feature which determined the degree of vibration that was acceptable. Fig. 2 shows the main gear, in which tangential, spring-restrained movement is provided between the gear rim and the gear center.

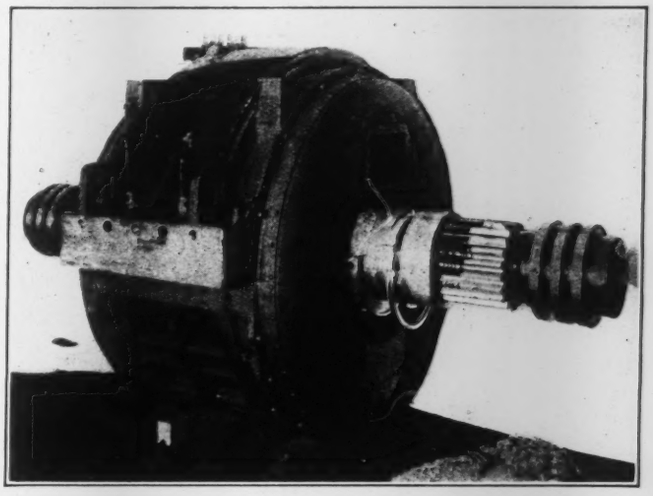


Fig. 1 Motor of Norfolk & Western Electric Locomotive

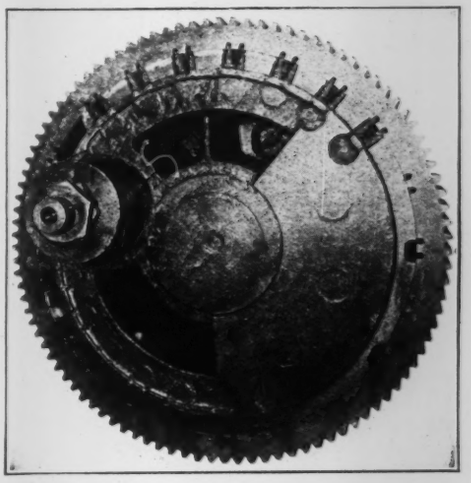


Fig. 2 Main Gear, Norfolk & Western Electric Locomotive

When the locomotive is hauling its train up a grade, the pinion drives the gear. This service will be referred to hereafter as "motoring." This service must be performed with either end of the locomotive leading; that is, the pinion drives the gear either clockwise or counterclockwise.

When the locomotive with its train is descending a grade, the main motors supply the braking resistance and return energy to the power line. This service will be referred to hereafter as "regenerating." While regenerating, the gear drives the pinion, and this drive, again, may be either clockwise or the reverse.

Analysis of Tooth Engagement

When the mating teeth of a pair of gears engage, forces are

[1] Chief Mechanical Engineer, Westinghouse Elec. & Mfg. Co. Mem. A.S.M.E.

Contributed by the Machine Shop Practice Division and presented at the Annual Meeting, New York, November 30 to December 4, 1925, of The American Society of Mechanical Engineers. Abridged.

set up parallel and perpendicular to the line of action. These forces may be analyzed separately, or they may be combined and the analysis directed to the resultant. The former method has been adopted because it seems to lend itself better to a clear understanding of the actions which take place. The following phase of the analysis is based upon the assumption that the tooth contour is the closest practicable approximation of the involute form.

Referring to Fig. 3, it is evident that just prior to arrival at the indicated position, the entire motor torque was carried at *A*. When the normal pitch *N* is equal on the driving and driven gears, the next pair of mating teeth come smoothly into engagement as they enter the line of action at *B* (neglecting deflections).

Going a step further, however, we find that deflections interfere with this smooth engagement. Analyzing deflection in detail, we find that it occurs in three ways with new gears:

a The flattening down of high spots

b Surface depression sufficient to develop areas adequate for the support of the existing normal pressure

c Cantilever deflection of working teeth. These deflections, while small, are larger by a material percentage than indicated by the usual cantilever formulas, due to the disturbance of base that occurs when a short, deep cantilever is loaded.

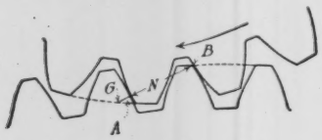


FIG. 3 CORRECT ENGAGEMENT OF MATING TEETH. NORMAL PITCH EQUAL ON DRIVING AND DRIVEN GEARS

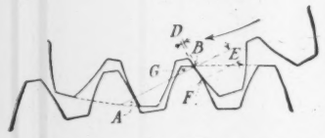


FIG. 4 PREMATURE ENGAGEMENT OF MATING TEETH. NORMAL PITCH LONGER ON DRIVEN THAN ON DRIVING GEAR

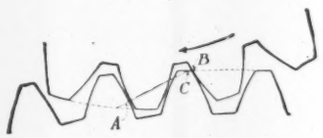


FIG. 5 PREMATURE DISENGAGEMENT OF MATING TEETH. NORMAL PITCH LONGER ON DRIVEN THAN ON DRIVING GEAR

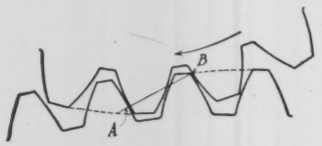


FIG. 6 DELAYED ENGAGEMENT OF MATING TEETH. NORMAL PITCH SHORTER ON DRIVEN THAN ON DRIVING GEAR

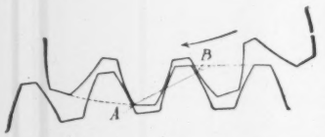


FIG. 7 DELAYED DISENGAGEMENT OF MATING TEETH. NORMAL PITCH SHORTER ON DRIVEN THAN ON DRIVING GEAR

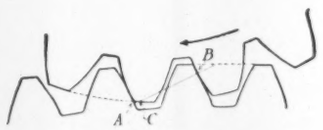


FIG. 8 DELAYED ENGAGEMENT OF MATING TEETH. NORMAL PITCH SHORTER ON DRIVEN THAN ON DRIVING GEAR

The resultant effect of all three deflections is to shorten the active normal pitch of the driving gear, and to lengthen the active normal pitch of the driven gear. Thus, the caption under Fig. 3 is true in a precision sense only when rolling the gears without load, if they are made with their normal pitches strictly equal.

Fig. 4 shows an exaggerated view of what tends to happen as a result of the deflections noted. Premature engagement occurs at *B*.

When the normal pitch of the driven gear, as manufactured, is measurably longer than the normal pitch of the driving gear, the tendency toward premature engagement may become still more pronounced. If, under this condition, the angular velocity is high, and if the teeth are soft and comparatively rigidly associated with masses of great inertia, the flank of the driving tooth and the tip of the driven tooth will undergo permanent distortion and wear. If, however, the teeth have been sufficiently hardened by heat treatment to enable them to sustain within their elastic limit the forces set up by this dynamic engagement, the positions indicated in Fig. 5 will be assumed. The teeth at *A* will break contact as the teeth at *B* pick up the load, thus shortening the length of the line of action to slightly more than one normal pitch. (It will be noted that the line of action is no longer a single straight line, but follows the line *BCA*, Fig. 5. The portion *BC* will be somewhat modified by local surface deflections, but it is sufficiently accurate to serve as a diagram of what actually occurs.)

This readjustment of the relative angular positions of the driving and driven gears can occur in the brief time element allowed, without setting up destructive locally applied forces, only by virtue of the elastic characteristics of the entire associated structure. When the elastic conditions, masses, and frequencies bear to each other a relation permitting resonance to occur, the situation becomes serious. The engineer must therefore predetermine as far as possible that the relation of these fundamentals is satisfactory.

In certain one-way drives where unsatisfactory operation was recently investigated and corrected, the basic reason was found to be a normal pitch of the driven gear longer than that of the driving gear.

In installations where the pinion drives the gear and little or no back-driving occurs, the sensible course is to avoid dipping into the difficult and somewhat indeterminate investigations of resonant response to premature tooth engagement. This may be approached by making the normal pitch of the driven gear shorter than that of the driving gear by an amount sufficient to compensate for the deflection of the active teeth, as shown in Figs. 6 and 7.

The limits should be set at values also insuring that premature engagement will be avoided even when the most undesirable extremes of commercial tolerances chance to be cumulative.

In the locomotive installation under discussion, however, the issue is more complicated. In all the illustrations the pinion has been shown as the driving gear, which is the motoring condition. But every departure from a precise equality of normal pitch of the gear and pinion which may be adopted to improve motoring performance serves to deteriorate the performance while regenerating.

The best overall performance therefore becomes a compromise and involves a review of the relative motoring and regenerating mileages and loadings for which the locomotives are intended.

Referring further to the action occurring when the normal pitch of the driven gear is relatively short, it will be seen from Fig. 8 that the teeth at *B* remain out of contact till the teeth at *A* have passed beyond the nominal end of the line of action, again departing from a single straight line and following the patch diagrammed by the line *BCA*.

Evidently there must be a readjustment of the relative angular positions of the driving and driven gears between the positions of Figs. 7 and 8 before the teeth at *B* can assume the load. It is obvious that here again there are possibilities of dynamic engagement and resultant resonance which demand investigation. With identical discrepancies of normal pitch, the dynamic forces arising in connection with the premature engagement shown in Figs. 4 and 5 are much more severe than those accompanying the delayed engagement shown in Fig. 8.

The analysis immediately following will show that premature engagement is the exciting cause of severe transient accelerations of the rotating masses, while delayed engagement follows less severe angular accelerations which are produced by the driving torque.

The accelerations of premature engagement are directly opposed by the torque of the motor and the moment of inertia of the rotating parts on the driving side of the system, and on the driven side are opposed by the moment of inertia of the gear rim, the friction between the gear rim and the gear center, and the driving-torque reaction as applied to the gear rim through the radial leaf springs with their inherent frictional damping. It is apparent that the tendency of all inertias, live forces, and frictions is to increase the

severity of the dynamic conditions accompanying premature engagement. The only relief offered by the system lies in the elastic characteristics of the entire structure.

Some of the conditions surrounding delayed engagement are in marked contrast to those just described. The forces active in producing the angular accelerations required to close the gap at B, Fig. 7, and thus reach the positions shown in Fig. 8, are the torque of the motor and the reactions of the radial leaf springs in the gear. The conditions to this point are akin to those of premature engagement, except that cause and effect have changed places. But all inertias and frictions tend to reduce the velocities attained during the closing of the gap at B, Fig. 7, and therefore tend to reduce the forces set up at the instant that this gap is closed. Also, the tendency of tooth deflections is to narrow this gap, thus reducing the angle through which acceleration must occur, as contrasted with premature engagement, where tooth deflections increase the space through which accelerations are effective. And finally, under the conditions of delayed engagement, the various masses are not free to respond to the forces enumerated thus far, as the relative velocities of the driving and driven masses are dictated by the continuing contact of the teeth at A, Fig. 7.

As before, the elasticity of the system cushions the shock attendant upon delayed tooth engagement.

From this analysis it is clear that the relative angular velocity of the driving and driven teeth as they come into delayed engagement, and the resulting impacts, are less than the corresponding occurrences with premature engagement.

Forces Perpendicular to the Line of Action

At this point in the analysis it would appear that the vibration accompanying premature engagement due to relatively short normal pitch on the driving element is characterized by about the same severity during motoring and regenerating. In actual service, however, we find that, with equal discrepancies, the vibration accompanying regeneration is materially more severe than that occurring during motoring. It is therefore necessary to look further for the reason.

With the gears under discussion, the transient peak of normal pressure associated with the impact of premature engagement during regeneration occurs at a point more remote from the pitch point than the corresponding point during motoring. This is due to the long- and short-addendum teeth which are employed. Since the sliding component of the relative motion of mating teeth is a direct function of the distance of the contacting point from the pitch point, it follows that the rate of sliding during the premature engagement of regeneration is greater than that occurring during motoring, as shown in Fig. 9, where $\frac{1.35}{0.74} = 1.82$.

The product of normal pressure and coefficient of friction gives forces F_m, for motoring, and F_r for regeneration. These forces are directed perpendicularly to the line of action. The coefficient of friction is a function of the condition of the lubricant. This will be referred to later in more detail.

Fig. 9 shows clearly that the disturbing turning moment of tooth friction active upon the pinion, and therefore upon the entire rotor, is comparatively small when the pinion drives the gear, being represented by $F_m \times C$, but when the gear drives the pinion, with an identical normal pressure cycle, in the particular gearing under discussion it becomes 2.34 times as great, being represented by $F_r \times B$.

It will be noted that the entire load is assumed to be carried by one tooth, even at the ends of the line of action. In new gearing of the class under discussion this must be expected, as the precision essential to cause an actual division in line with theoretical perfection is too expensive, if at all possible.

The following tabulation gives the qualitative tendencies of the couples produced by tooth frictions:

	Pinion	Gear
Motoring:		
Direction of rotation	Clockwise	Counterclockwise
Direction of tooth-friction couple	Clockwise	Clockwise
Regenerating:		
Direction of rotation	Counterclockwise	Clockwise
Direction of tooth-friction couple	Clockwise	Clockwise

With Brown & Sharpe standard tooth forms the tooth-friction couples discriminate a little less against the regenerating condition in so far as their maximum value is concerned, though the ratio B/C is less favorable. Here again we face a compromise between the strength of the pinion teeth and the forces inflicted upon those teeth. The final selection appears to be beyond the possibility of pure analytic determination, and can be based only upon broad experience assisted by tests with the torsiometer or other similar instruments. These variable disturbing frictional couples tend to produce oscillations of the entire rotating and associated structures.

With normal lubrication and under the most severe conditions observed the oscillations outlined never became sufficiently violent to separate the teeth of the gear and pinion.

With the teeth of the gear and pinion dry and cutting, however, there is a possibility of extremely severe vibrations being produced

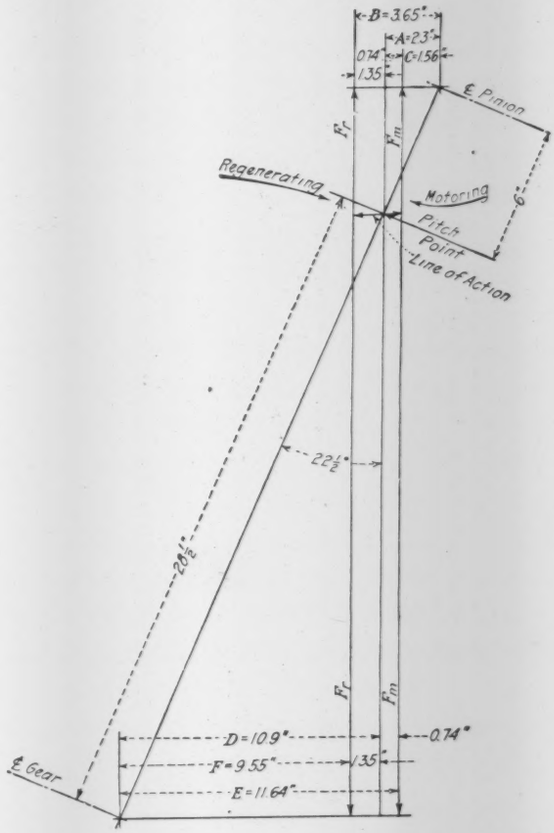


FIG. 9 MOMENT OF TOOTH FRICTIONS

$A = 6 \sin 22\frac{1}{2}° = 6 \times 0.3827 = 2.3$ in.
$B = 2.3 + 1.35 = 3.65$ in.
$C = 2.3 - 0.74 = 1.56$ in.
$\frac{B}{C} = \frac{3.65}{1.56} = 2.34$
$D = 28.5 \sin 22\frac{1}{2}° = 28.5 \times 0.3827 = 10.9$ in.
$E = 10.9 + 0.74 = 11.64$ in.
$F = 10.9 - 1.35 = 9.55$ in.
$\frac{E}{F} = \frac{11.64}{9.55} = 1.22$

by the friction couples. Under this condition, there is also the possibility of the occurrence of higher frequencies, due to the alternate seizing and slipping of the contacting surfaces: that is, a chattering slip. This has received confirmation in service as far as the severity of the vibration is concerned, as dry gears have been found where destructive vibration was promptly quieted by feeding heavy lubricant directly into the mesh.

From this analysis it is obvious that when a large amount of regeneration is required by the service, and particularly when full-load torque is developed while regenerating, the engineer must adopt a shorter normal pitch on the pinion than he would employ if heavy regeneration were not required.

Tip Relief

A discussion of tip relief seems to be unavoidable since the prime reason for the need of tip relief is found in the discrepancies of normal pitch, and also because in setting up a normal-pitch indicator the radial extent of tip relief must be considered to insure checking

the normal pitch at the extreme outer end of the true involute part of the tooth contour.

Reference has been made to the tendency existing concurrently with premature engagement to produce permanent deformation of the involute contour. A similar tendency is present with delayed engagement, the tip of the driving tooth and the flank of the driven tooth being subjected to high local pressure over the portion CA of the line of action, Fig. 8.

When the conditions surrounding the installation are sufficiently circumscribed to render some degree of tooth wear inevitable, as is the case with heavy-traction electric locomotives, it is evident that the departures from the involute which have been mentioned as possibilities will become actual to an extent largely dependent upon the discrepancies in normal pitch. This wear is likely to become noticeable first on the flank of the gear tooth at A, Fig. 8, for the following reasons:

a With the long- and short-addendum teeth employed, there is, as previously explained, more sliding of the teeth at the recess end of the line of motoring action than at the approach end, and therefore the work of friction is greater at this point. The sliding action consists of the sliding of a relatively long portion of the pinion tooth over a small portion of the gear tooth, thus concentrating the wear on the gear.

b The control of the permanent distortions of the gear during the heat treatment employed on the gearing under discussion, dictates drawing the gear back to a slightly softer condition than is necessary and feasible for the pinion.

c Due to the angles at which the teeth approach each other during motoring and regenerating, the tooth surfaces depart further from tangency when regenerating, and this amplifies the gouging tendency. This is more clearly understood when it is realized that without tip relief, the area which is built up by deflection to support the load must be developed on a portion of the tooth contour which lies all on one side of the nominal line of action. Thus, with any combination which permits the slightest premature engagement, the absence of tip relief invites gouging. During sustained regeneration there is also more tendency gradually to thin the film of lubricant at the critical area of initial contact, due to the sliding characteristic noted.

The engineer must therefore consider whether the best overall results will be achieved by adopting the closest available approximation to the involute, trusting that the gears will work out their own correction during service operation, or whether he should approximate those corrections in the manufacture of the gears. We shall first discuss the methods for working out the details of tip relief, and follow with some of the arguments concerning the propriety of its adoption.

The maximum working pitch-line velocity of the locomotive gearing used for illustration is about 38 ft. per sec. A normal pitch of the driven gear 0.007 in. shorter than that of the driving gear was found to be too far from equality and caused undesirable vibration, particularly during regeneration. Neglecting elastic relief, we find that at the maximum velocity the time required to travel 0.007 in. is about one sixty-five thousandth of a second. This is not an accurate evaluation of the time involved in completing the adjustment cycle, but it emphasizes the fact that only a very small time element is allowed for the adjustment of the relative angular positions of the driving and driven masses.

When the general average discrepancy between the normal pitches of the driving and driven gears D, Fig. 4, is known, a simple calculation will determine the length of the interference E, Fig. 4.

Neglecting the deflections due to the engagement at A, if the tip of the driven tooth were formed to match the involute contour of the driving tooth from G to F, the initial engagement would be smooth, followed immediately by accelerations caused by rolling over the hump at F on the driven tooth. This would be less severe than if no tip relief were adopted. The cycle immediately following initial engagement may be further eased off, however, by adopting a form of relief curve that is tangent to the driven-tooth contour at a driven-gear radius less than that of the point F, and tangent to the driving-tooth contour at a driving-gear radius less than that of the point F. By a similar method it is equally feasible to work out the tip relief to reduce the severity of delayed tooth engagement.

CHORDAL-PITCH INDICATOR

After considerable study it was decided to base the selection of gears and pinions upon the uniformity of chordal pitch. To be more explicit, a gear was to be tentatively considered good if its chordal pitch was fairly uniform. This chordal pitch might vary slightly from that of the pinion with which the gear was to mate, without condemning the gear or the pinion. The reason for this basis of selection was that unsatisfactory performances were always characterized by some cycle of vibration and noise, which was in phase with the revolutions of the gear. This cycle had decided individuality in many of the gears, and there seemed to be a reasonable expectation that a gear of good uniformity would reduce this cycle within acceptable limits.

After gears sufficient for equipping two or three locomotives were ground, the chordal-pitch indicator shown in Fig. 10 was developed. This indicator has hardened registering points which align it relatively to the side and to the ground bore of the rim. A hardened pin contacts with a tooth at the pitch line, and a

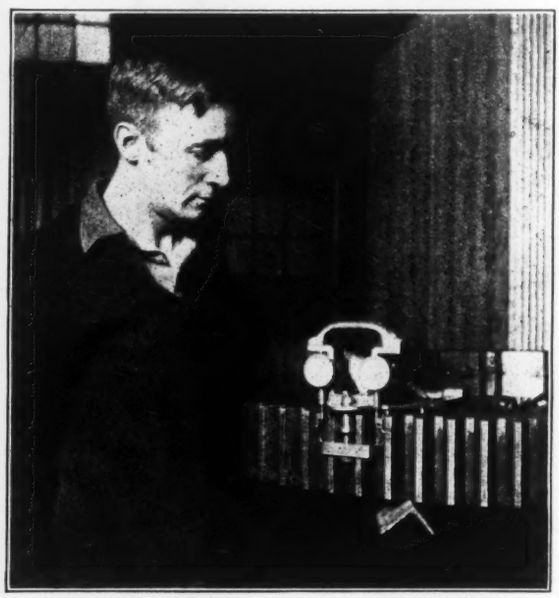


FIG. 10 CHORDAL-PITCH INDICATOR

dial indicator with the usual bell-crank attachment contacts with the adjacent tooth at the pitch line. For purposes of record, in inspecting these gears the start was always made on a witnessed tooth. With the instrument in clockwise recording position on the first tooth, the dial was set at zero. With the contact pin in the same space, the indicator was swung to the other hand and the counterclockwise calibrating setting at zero adjusted on the second dial indicator. The indicator was then entered on the next tooth and the readings were recorded as No. 1. All teeth were measured and recorded successively, the hundredth readings being taken on the tooth of original dial adjustments, which must therefore read zero and check that the calibration of the indicators had not been altered. The readings were then plotted and the datum line corrected to read the average.

It will be seen that the plotted values were the variations from the average chordal pitch and did not record the actual pitch values.

All the gears that had been ground up to this time were plotted, and it was found that the best that could be expected from the facilities then available was a variation from average chordal pitch of ± 0.004 in. This value was therefore adopted as the limit for the locomotives involved. Every tooth that exceeded this limit was retrimmed on the machine and brought within the limit. As the machine aged, it was necessary to regrind some gears.

The unsatisfactory unmatched and unground gears on the first locomotive were replaced by gears selected by means of the chordal-pitch indicator, and within the limits noted. Their performance was perhaps a little inferior to that of the unground but matched gears of the second locomotive, which was very disappointing.

In the meantime another gear-grinding machine was being brought through by the Newark Gear Cutting Machine Company. As soon as this machine was installed, it was tried out, and it was found practicable to cut the limit of departure from average chordal pitch to ±0.002 in. A trimming device also was made by the same company, which gave much better contours.

The third locomotive was equipped with gears and pinion within this limit. The preliminary trials of this locomotive showed that the gearing was still unsatisfactory.

These events led to the analysis outlined in this paper, which shows the importance of a proper relation of the normal pitch of the gear and the pinion.

Normal-Pitch Indicator

The normal-pitch indicator shown in Fig. 11 was then developed. This outfit included segments of the base circle bolted to the gear in proper concentric relation, and a tangent frame. This frame determined the location, upon the common normal of adjacent teeth, of a dial-indicator finger at the outer end of the involute contour of one tooth, and of a locating plug on the adjacent tooth. The dial was set to a calibrating plug gage to read zero at the exact calculated normal pitch. This indicator therefore read the

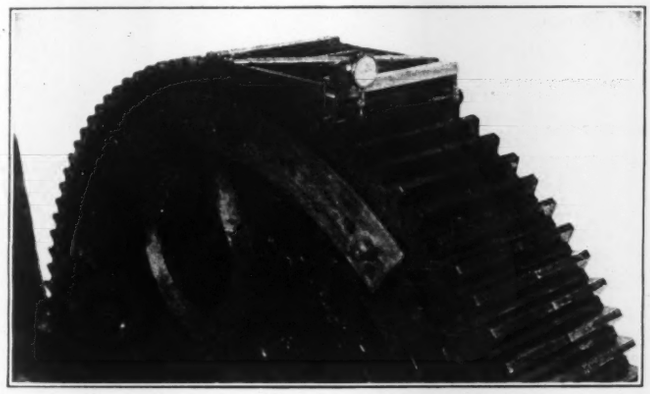


Fig. 11 Normal-Pitch Indicator

actual normal pitch instead of a relative value as in the chordal-pitch indicator. This indicator was found to be very clumsy to handle, and it had the serious limitation of all indicators developed to this time: namely, it could be applied only at lateral locations about an inch away from the edge of the gear.

It was useful, however, in the practical development of the fact that variations of plus or minus a sixteenth of an inch in the radius of the base circle produced errors so small as to be within the accuracy of reading of the indicator. As this variation more than covered the range of permanent shrinkage of the gears during heat treatment, it was at once evident that a very convenient instrument could be made which would read at any point across the face of the gear. This instrument could register on either the tips of the teeth or the bottoms of the tooth spaces, or the registering parts could bottom on the flanks of two adjacent teeth. The combination shown in Fig. 12 was adopted. A hardened and ground cylindrical member bottoms on the flanks at a depth which brings its contact on that common normal to two tooth contours which passes through the outer end of the involute part of the contour of one of the two teeth, at which point an indicator finger is arranged to make contact. The alignment of this common normal is determined, within the required accuracy, by the locating leg remote from the indicator and registering in the bottom of a tooth space. The length of the contact cylinder is sufficient to insure a firm, square setting of the indicator.

This indicator is made adaptable to all $1^3/_4$-diametral-pitch gears between 50 teeth and a rack, by means of a range of contact cylinders of suitable diameters, and a range of locating legs of suitable length.

A second normal-pitch indicator was developed covering the remaining range of $1^3/_4$-diametral-pitch gears and pinions. This particular type of normal-pitch indicator may become unreliable for pinions with less than, say, 17 or 18 teeth, as the line of indication may depart too far from the line of action.

The check-up on the range of normal pitch of the gears showed that they ran quite uniform, the variation being about 0.004 in.

The pinions also were quite uniform, the variation being about 0.002 in., but the actual value of their normal pitch was about 0.007 in. longer than that of the gears, and this was the principal reason, from the gear standpoint, for the unsatisfactory operation. While the motoring operation was better than it would have been had the normal pitch of the pinions been shorter than that of the gears by the same amount, it was too far from equality.

A set of pinions was produced with a normal pitch 0.002 in. shorter than the gears, and while this discrepancy was still on

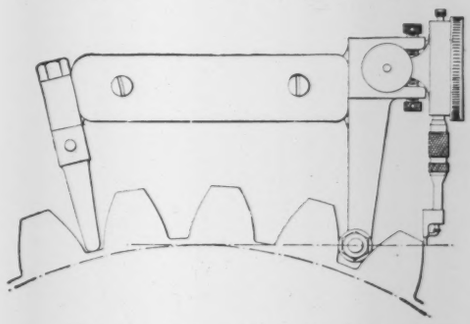


Fig. 12 Normal-Pitch Indicator

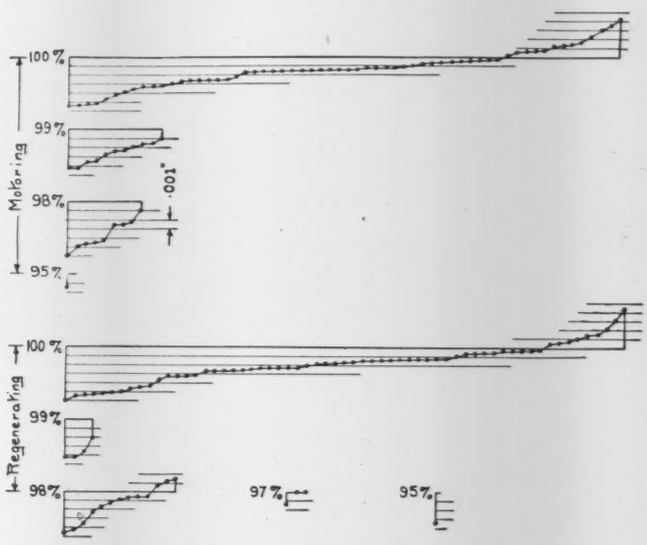


Fig. 13 Influence of Normal Pitch on Gear Performance on Test Track

(Percentage indicated is rating of gearing on test track. Each point represents a gear and pinion test. Distance below base indicates normal pitch of pinion is less than that of gear.)

the less desirable side of equality for the motoring condition, it proved to be about the best compromise for the overall service of motoring and regenerating, and corrected the difficulty that had been experienced.

A considerable range of installations using gears and pinions as they clean up in grinding out heat-treatment distortions, is under way and is developing in some measure the limits of discrepancy of normal pitch within which acceptable operation can be achieved with the particular gearing and service under discussion. The results of this class to date are outlined in the following paragraphs.

Analysis of Influence of Normal Pitch on Gear Performance on Test Track

All gears after installation in the complete locomotive are given a performance rating on the test track. This rating is based upon noise as measured by the ear of a trained observer, and amplitude of vibration as judged by the hand of the same observer. The parts checked for vibration amplitude are brushes, brushholders, and leads. The gears giving the best performance are rated 100 per cent. The lowest passing grade is 95 per cent.

In each of the graphs of Fig. 13 the base line indicates an equality of the normal pitches of the gear and pinion. Values below the base line indicate that the normal pitch of the pinion is less than that of the gear by the number of thousandths of an inch plotted. Values above the base line indicate that the normal pitch of the pinion is greater than that of the gear by the number of thousands of an inch plotted.

Reference to the graphs shows that satisfactory performance has been secured over the entire range from minus six thousandths to plus four thousandths as the value of the expression, "normal pitch of pinion minus normal pitch of gear." This is roughly true under the conditions of both motoring and regenerating. Practically all performance of a grade less than 100 per cent occurred with the normal pitch of the pinion less than that of the gear.

The outstanding fact of this study is that only with a high degree of accuracy in the entire mounting can the variations of normal pitch be permitted to go as high as indicated in the graphs. A considerable number of mountings were encountered in the early stages of the work where departures from accuracy of normal pitch gave unsatisfactory performance, and these cases were corrected by following the tendency of the theory in the proportioning of the gear and pinion. During the latter stages of the work, the accuracy was held well within the limits indicated, and nearly every gear and pinion was inside the satisfactory performance range on its first trial.

Conclusions for Locomotive Motoring and Regenerating Service

The conclusions for locomotive motoring and regenerating service are:

a The normal pitch of the driving and driven gears must lie within limits determined on the basis which has been set forth.

b The tips of the teeth should be relieved on the basis outlined. This is more vital on the pinion than on the gear.

c Acceptable gear operation can be secured in locomotive installations where back-driving is essential.

d The degree of quietness of gear operation can be fairly well predetermined by checking the known salient characteristics of the gears and mounting.

e Selection can be made between gears that require grinding and those that may successfully be put into service as they come from heat treatment.

f An adequate supply of proper lubricant must be present on the teeth during the entire working cycle of the locomotive.

g Data must be accumulated for a considerable period to determine the widest limits that may be adopted for the salient variables in order to make costs as reasonable as possible.

Characteristics and Uses of Ground Gears

THERE is at present an increasing demand from engineers for high-duty spur gearing, and yet the ground gear is practically a new mechanical product, except in motor-car service, and is comparatively little known in general engineering. The two outstanding characteristics of the ground gears are extreme accuracy and the possibility of making a straight-tooth gear of material with any desirable properties. Any alloy-steel or heat-treatment specification can be satisfied, and even with the hardest material an accuracy of tooth finish with limits of error even smaller, with few exceptions, than are demanded in cylindrical grinding, can be obtained. This makes it possible to eliminate objectionable noises.

Experience in motor-car work has demonstrated that to secure quiet running, errors in gear-tooth shape, in placement of tooth, and in indexing must not exceed 0.0003 in. Only grinding permits accomplishing such precision, and then only with the employment of the most accurate and refined grinding machine, together with special experience, highly specialized measuring instruments, and extraordinary care in inspection and supervision.

In straight spur gears all tooth action takes place by sliding and all tooth contact occurs on a line. In addition the load is constantly transferred from one toothed surface to another. This action takes place in a very short time, in many cases 100,000 or even 200,000 times a minute. Because of this the indexing must be especially accurate and the tooth finish smooth. Only the grinding wheel can do this.

When the teeth of gears are to be ground, reasonable distortion need not be feared, and this permits of the use of material which can be selected solely on account of its physical properties, and can therefore be made of minimum dimensions.

Although the greatest distortion takes place in such steels, these give the longest life and bear the heaviest tooth loads. Hardening distortions vary with the size and shape of gears, and must obviously be kept within certain limits. In small gears as used in the motor-car box, a grinding allowance from 0.003 in. to 0.005 in. is necessary on each side of the teeth, or from 0.006 in. to 0.010 in. on the tooth thickness. On large diameters up to, say, 30 in., 0.040 in. on the tooth thickness is necessary or all teeth will not completely finish.

With full theoretical efficiency and no limitations respecting choice of material, straight spur gears can be designed with minimum dimensions. This is valuable in many cases where restrictions are imposed by weight and space. A good example is found in a pair of reduction gears, many of which are in service in a well-known makers' airplane engine, with the following dimensions: Gear, 12.46 P.D.; pinion, 5.34 P.D.; teeth, 3.9326 pitch; width of gear, 2.6 in.; hp. transmitted, 650; load per inch of face, 3450 lb.; peripheral speed of gear, 2650 ft. per min.

Any number of gears in motor-car gear boxes are in use carrying a load of over 3000 lb. per inch of face. As a contrast, many electric railway gears are in use carrying loads of only 1200 lb. per inch of face. Theoretically, the latter might be reduced in width to one-half the size commonly used, that is, if properly selected material were employed and the teeth were accurately finished by grinding after hardening. For railway gears the factor of safety on the gears as now made is 16 on the elastic limit. The question is: Could the factor of safety be reduced to 5 without danger of rupture from shock loads? So far as is known, no tests have been made covering this possibility. The gear in the motor car stands enormous shocks and great abuse, and rarely fails.

It is suggested that many cases of the so-called "pitting" are directly due to rough or inaccurate finish, the theory being that rough projections on the teeth are pushed by sliding action toward the pitch lines, and near the pitch line particles of metal are pressed into the surfaces of the teeth, causing these well-known blemishes. In theory it seems that the ground gear should have the longest life, as it is a fact that in nearly all mechanical action the maximum wearing qualities exist in those surfaces which most nearly approach mathematical perfection. Service tests have shown that railway transmission gears with ground teeth outlast all others.

It is quite possible that there will be distinct advances in gear-tooth service when more gears are designed with a long line of action and with as many teeth in contact as possible. Multiple-tooth contact is, however, not of much practical value in gears when they are finished by ordinary cutters or are hardened after cutting. The slightest imperfections of indexing or of variation in form prevent division of the load, which should in theory be evenly distributed on two or more teeth.

Backlash, under certain conditions, directly affects the life of gearing. A certain amount is just as necessary to good gear cutting as clearance is to good spindle running. But the amount of it must be strictly under control, and it has already been seen that variation can be limited to a fraction of a thousandth of an inch by grinding, as compared with variations ten times as great in cut and hardened gears. Uniform teeth forms and uniform backlash are, of course, natural accompaniments. (H. F. J. Orcutt in *Engineering*, vol. 120, no. 3126, Nov. 27, 1925, pp. 691-694)

Some Comparative Wear Experiments on Cast-Iron Gear Teeth

By GUIDO H. MARX,[1] LAWRENCE E. CUTTER,[2] and BOYNTON M. GREEN,[3] STANFORD UNIVERSITY, CAL.

THE experiments reported in this paper had their origin in a suggestion of Mr. Luther D. Burlingame, and were made in the laboratories of the mechanical-engineering department at Stanford University. At its start the work had the coöperation of the Engineering Foundation, which paid the entire cost of the construction of the testing apparatus. The Foundation withdrew from connection with the investigation in December, 1920. The gears for the preliminary runs were furnished, at the nominal cost of the castings, by the Pacific Gear and Tool Works, of San Francisco, and those for the extended runs were generously donated by the Brown & Sharpe Manufacturing Company.

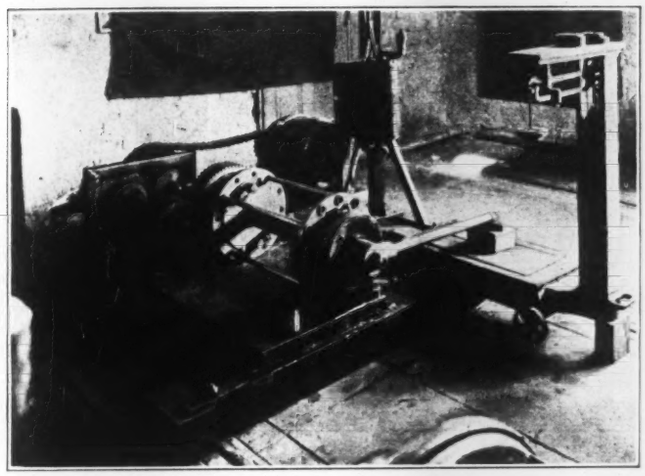


FIG. 1 APPARATUS AS SET UP FOR LAST FOUR SERIES OF TESTS

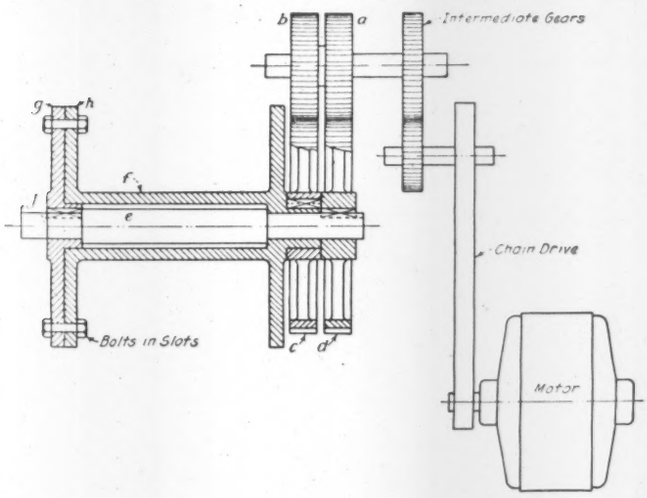


FIG. 2 LAYOUT SHOWING PRINCIPLE OF OPERATION OF APPARATUS USED IN TESTS

All of the gears were of cast iron and had a width of face of $1^1/_2$ in. No analysis was supplied of the material of the set furnished by the Pacific Gear and Tool Works. Those furnished by the Brown & Sharpe Manufacturing Company were made from a single pour and used a mixture termed their "medium cast iron," being a standard gray iron with 15 per cent steel and having the following approximate analysis according to data furnished by them:

Silicon	2.25	Combined carbon	0.50
Sulphur	0.089	Graphitic carbon	2.85
Manganese	0.65	Total carbon	3.35
Phosphorus	0.45		

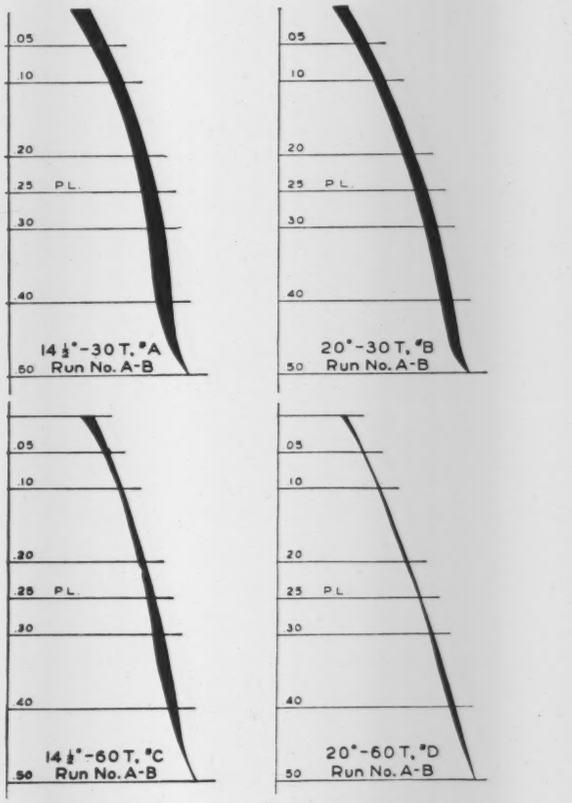


FIG. 3 AVERAGE ORIGINAL AND WORN FORMS OF THE FOUR SETS OF ENGAGING TEETH OF SERIES 1, RUN A-B

Cast-iron gears furnished by Pacific Gear & Tool Works.
30T and 60T, 4-pitch, standard-depth, 14½-deg. involute against 30T and 60T, 4-pitch, standard-depth, 20-deg. involute. All 1½-in. width of face.

Pitch speed	1270 ft. per min.
Load per in. width of face	1867 lb.
Total revolutions, gears	326,656
Average depth of wear 30T, 14½-deg. involute pinion	0.0201 in.
Average depth of wear 30T, 20-deg. involute pinion	0.0159 in.
Ratio of wear 14½-deg. pinion to 20-deg. pinion	1.27 to 1
Average depth of wear 60T, 14½-deg. involute gear	0.00883 in.
Average depth of wear 60T, 20 deg. involute gear	0.00402 in.
Ratio of wear of 14½-deg. gear to 20-deg. gear	2.19 to 1

All pinions had thirty teeth and all gears sixty teeth. Three types were included in the test: (1) 4-pitch, $14^1/_2$-deg. involute, standard depth; (2) 4-pitch, 20-deg. involute, standard depth; (3) 4/5-pitch, 20 deg. involute, stub-tooth.

The apparatus was designed by Prof. L. E. Cutter and constructed in the mechanician shop of Stanford University. While it has proved entirely satisfactory for the purpose of purely comparative tests, such as those reported upon here, it has shown limitations which would make modifications of design necessary if experiments were attempted to derive actual coefficients of wear. Fig. 1 shows a photograph of the apparatus as set up for operation for the last four series of tests. During runs the lever shown resting on the platform scales is removed. The principle of operation is very simple.

Referring to Fig. 2, the two pinions *a* and *b* of the two types of teeth to be comparatively tested are keyed to the same shaft,

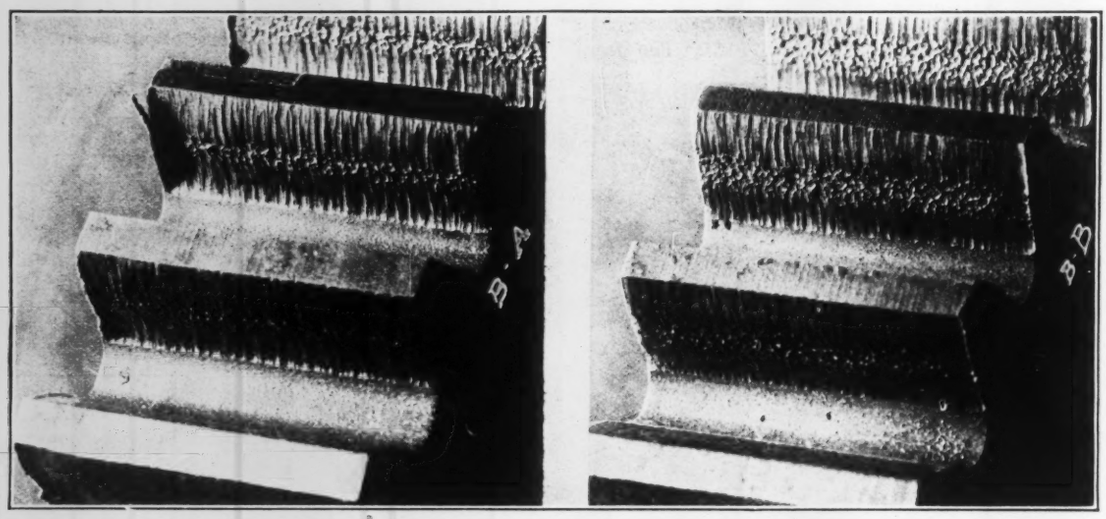
[1] Professor of Machine Design, Stanford University. Mem. A.S.M.E.
[2] Associate Professor of Mechanical Engineering, Stanford University. Mem. A.S.M.E.
[3] Assistant Professor of Mechanical Engineering, Stanford University. Assoc-Mem. A.S.M.E.

Contributed by the Machine Shop Practice Division and presented at the Annual Meeting, New York, November 30 to December 4, 1925, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Abridged.

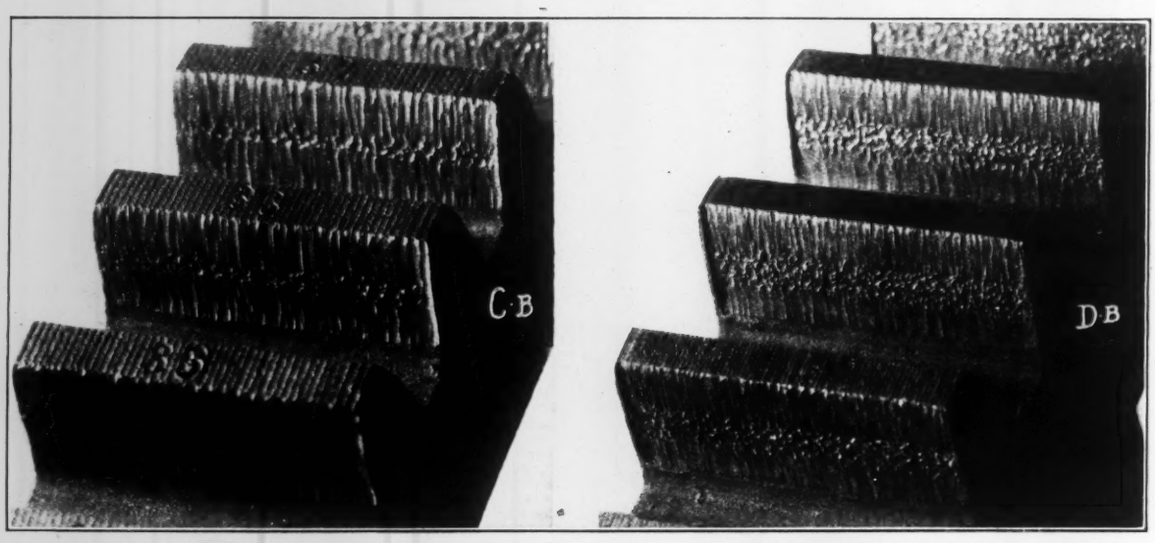
thus having no motion relatively to each other. This shaft is motor driven through the medium of a Morse chain drive and a pair of intermediate steel gears. Gear d meshes with pinion a and is keyed to shaft e to which the flange plate g is fastened. Gear c meshes with pinion b and is keyed to the quill f carrying the flange plate h.

Blocking the pinions a and b—the bolts connecting g and h having previously been loosened—a lever is fastened to the shaft e at j and by means of a small jack resting on a platform scale a definite load is put on the engaging surfaces of a and d. Obviously this load can be put on either face of the engaging teeth, are directly keyed but are held by six $^3/_8$-in. steel pins in jig-drilled holes, insuring identical adjustment.

Before each run the teeth of each pinion and gear employed were carefully measured at radial depths from the top land differing by 0.05 in. Complete dimensions were taken of every tenth tooth, and pitch dimensions of each tooth. Ordinary gear-tooth micrometer calipers were employed. Considerable time and expense were lost in trying to construct a more accurate measuring device. After a run was completed, the teeth were again accurately calipered and the results tabulated. The differences between the corresponding measurements gave the wear on the chord lines.



14½ deg.—30T—No. A 20 deg.—30T—No. B



14½ deg.—60T—No. C 20 deg.—60T—No. D

FIG. 4 ACTUAL APPEARANCE OF WORN SURFACES OF TEETH SHOWN IN FIG. 3 AT END OF RUN

involving merely a transfer of the platform scales from the right to the left side of the shaft. Care is exercised to make certain that all slack of the engaging teeth of b and c is then taken up. Next, the bolts holding the flange plates together are tightened and the loading lever and blocking removed. The result is that the shaft and quill transmit, through torsional stress, the same pressure to the engaging teeth of b and c, oppositely directed, that has been placed on the teeth of a and d. The entire quill and shaft spider is mounted on ball bearings and rotates as a whole. The pinion shaft is also mounted on ball bearings. Consequently, practically the only power the motor need supply is that required to overcome the friction at the engaging teeth. As actually constructed the mechanical details are considerably more refined and complex than here indicated. Thus, for example, none of the pinions or gears

The averages were then computed and careful drawings made 20 times full size. Two of these are shown reduced in Figs. 3 and 5.

After taking the measurements following a first run with a given set of gears, the flange bolts were loosened and a load next applied on the reverse, unworn, sides of the teeth. Upon the completion of the second run the teeth were again accurately measured and the wear on the second set of engaging surfaces determined. The test was then repeated with a second set of identical gears; but—in order to made sure that there was no effect due to the relative position in the apparatus of the gears—for the duplicate test the type of gear form that had been placed next the spider in the first test was placed on the outside. As the results were always alike, it would appear that there was no effect due to the set-up.

TABLE 1 LIST OF GEARS USED IN TESTS

Series 1 Pac. G. & T. Wks.	Series 2 B. & S. Mfg. Co.	Series 3 B. & S. Mfg. Co.	Series 4 B. & S. Mfg. Co.	Series 5 B. & S. Mfg. Co.
No. A-30T-14½°	No. 6-30T-14½°	No. 5-30T-14½°	No. 1-30T-20°	No. 2-30T-20°
No. B-30T-20°	No. 4-30T-20°	No. 7-30T-20° (*a*)	No. 8-30T-20° (*a*)	No. 9-30T-20° (*a*)
No. C-60T-14½°	No. 15-60T-14½°	No. 16-60T-14½°	No. 11-60T-20°	No. 12-60T-20°
No. D-60T-20°	No. 14-60T-20°	No. 17-60T-20° (*a*)	No. 18-60T-20° (*a*)	No. 19-60T-20° (*a*)

NOTE: (*a*) indicates gears with stub teeth. All others are standard depth.

The extended data and computations are omitted and some of the results are set forth primarily in graphical form in Figs. 3 to 8, inclusive. The authors are not unfamiliar with the valuable theoretical discussions of tooth friction and tooth wear[4] but prefer to limit this paper to a report of their own actual experimental results.

Two preliminary runs were made to try out the apparatus. The first employed a tooth pressure of 523 lb. per in. of width of face and the gears were run in a grease bath. The pitch speed was 847 ft. per min. After 613,220 revolutions no measurable wear had taken place. The tool marks were just beginning to wear off as shown by a few bright areas, not uniform across the teeth. The gears were next washed off carefully with distillate to remove all grease, a load of 1075 lb. per in. of width of face placed on the teeth, and 1,256,448 revolutions run at a pitch speed of 847 ft. per min. The result showed visible but scarcely measurable wear, heaviest on the 30T, 14½-deg. involute pinion, but averaging less than 0.001 in. even there.

The gears used in the tests are listed in Table 1.

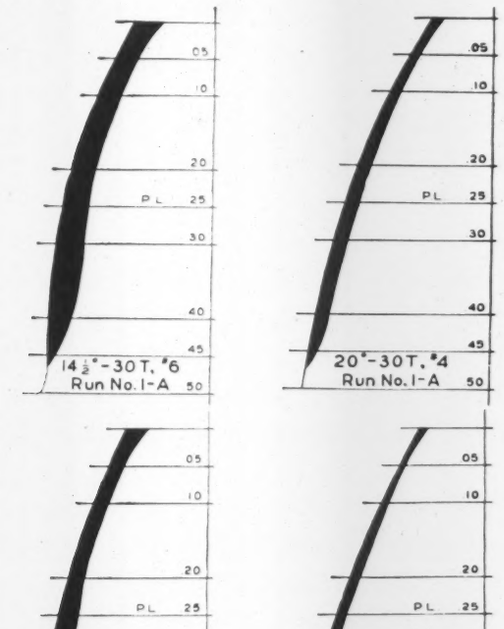


FIG. 5 AVERAGE ORIGINAL AND WORN FORMS OF THE FOUR SETS OF ENGAGING TEETH OF SERIES 2, RUN 1-A

Cast-iron gears furnished by Brown & Sharpe Manufacturing Company, 30T and 60T, 4-pitch, standard-depth, 14½-deg. involute against 30T and 60T, 4-pitch, standard-depth, 20-deg. involute. All 1½-in. width of face. This is a repetition, with somewhat different loads, of the combination used in Series 1; but in this series, the 20 deg. involute gears were placed on the far side from the spider, whereas they were adjacent to the spider in Series 1.

Pitch speed	1270 ft. per min.
Load, per in. width of face	1693 lb.
Total revolutions, gears	210,944
Average depth of wear 30T, 14½-deg. pinion	0.0322 in.
Average depth of wear 30T, 20-deg. pinion	0.0165 in.
Ratio of wear of 14½-deg. pinion to 20-deg. pinion	1.95 to 1
Average depth of wear 60T, 14½-deg. wear	0.02314 in.
Average depth of wear 60T, 20-deg. gear	0.0122 in.
Ratio of wear of 14½-deg. gear to 30-deg. gear	1.95 to 1

It is to be noted that in all cases of Series 1 and Series 2 the wear was heavier on the 14½-deg. teeth. The ratio of wear of the 14½-deg. teeth to that of the 20-deg. teeth varied between the limits 1.27 and 2.84, the average value of all the tests being 2.09 to 1.

[4] Particularly to be mentioned are the papers by O. Lasche, *Zeit. des Vereines deutscher Ingenieure*, vol. 43, and by K. Büchner, ibid., vol. 46.

In the two runs of Series 3 the authors encountered a discrepancy in the tooth load as measured by the scales and as measured by the torsional deflection of the spider ring. Whatever the actual total load on the teeth, however, it is at all times exactly the same on the two kinds of gears being comparatively tested. Save for a small amount of friction of shaft and quill (indeterminate), the action of the spider is equivalent to a torsional spring pushing equally against both supports (i.e., tooth-surfaces).

CONCLUSIONS

The deductions indicated by the foregoing comparative tests are:

a The standard-depth, 20-deg. involute tooth form appears to be a better one to resist wear than the standard-depth, 14½-deg. involute form.

b The stub-tooth, 20-deg. involute tooth form appears to be a better one to resist wear than the standard-depth, 14½-deg. involute form.

c The standard-depth, 20-deg. involute tooth form appears to be a better one to resist wear than the stub-tooth, 20-deg. involute form.

d Series 3 indicates predominance of the effect of pressure angle over the effect of ratio of arc of action to pitch arc.

e Series 4 and 5 indicate the importance of the effect of ratio of arc of action to pitch arc in distributing the load over several teeth, when employing the same pressure angle; and indicate that this effect more than counterbalances disadvantages due to the longer paths of relative rubbing and higher frictional velocity.

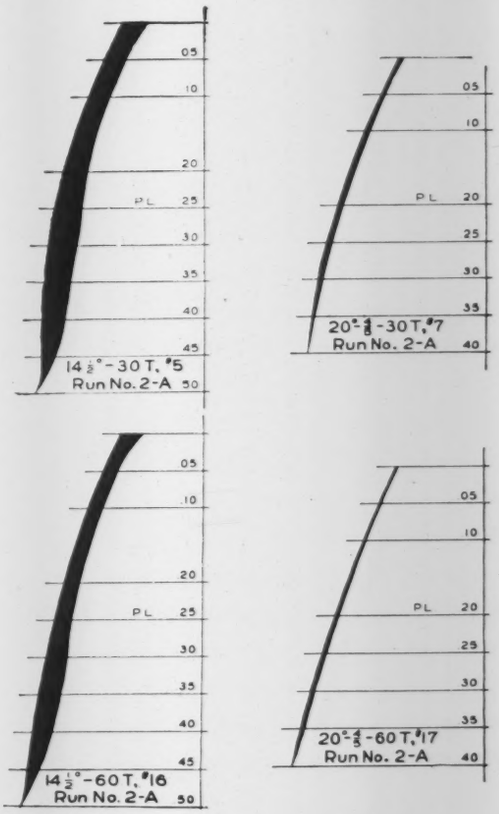


FIG. 6 AVERAGE ORIGINAL AND WORN FORMS OF THE FOUR SETS OF ENGAGING TEETH OF SERIES 3, RUN 2-A

Cast-iron gears furnished by Brown & Sharpe Mfg. Co., 30T and 60T, 4-pitch, standard-depth, 14½-deg. involute against 30T and 60T, 4/5-pitch, stub-tooth, 20-deg. involute. All gears 1½-in. width of face.

Pitch speed	1270 ft. per min.
Load per in. width of face	1307 lb.
Total revolutions, gears	279,808
Average depth of wear 30T, 14½-deg. involute pinion	0.0321 in.
Average depth of wear 30T, 20-deg. involute, stub-tooth pinion	0.0075 in.
Ratio of wear of 14½-deg. standard pinion to 20-deg. stub-tooth pinion	4.28 to 1
Average depth of wear 60T, 14½-deg. involute gear	0.0221 in.
Average depth of wear 60T, 20-deg. involute, stub-tooth gear	0.0055 in.
Ratio of wear of 14½-deg. standard gear to 20-deg. stub-tooth gear	4.02 to 1

The average ratio of wear, both runs, of the 14½-deg. standard-depth involute teeth when run in comparison with the 20-deg. involute stub teeth was 2.76 to 1.

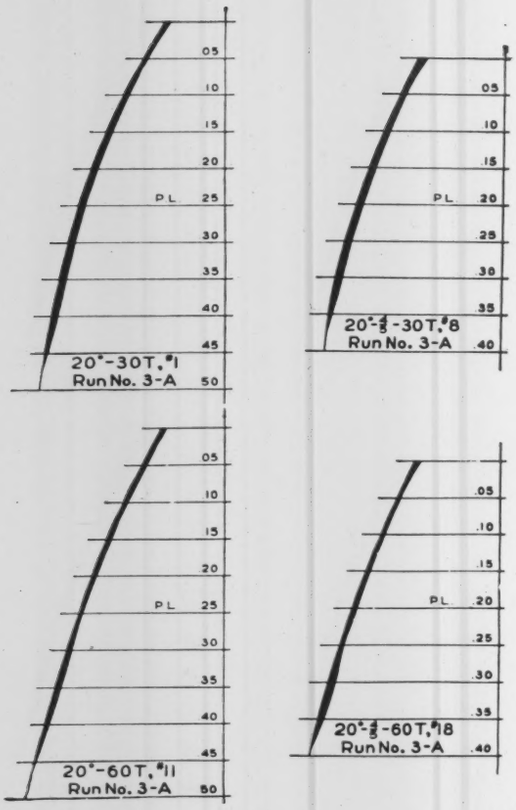


FIG. 7 AVERAGE ORIGINAL AND WORN FORMS OF THE FOUR SETS OF ENGAGING TEETH OF SERIES 4, RUN 3-A

Cast-iron gears furnished by Brown & Sharpe Mfg. Co. 30T and 60T, 4-pitch standard-depth, 20-deg. involute against 30T and 60T, 4/5-pitch, stub-tooth, 20-deg. involute. All gears 1½-in. width of face. Standard-depth teeth were placed next to spider.

Pitch speed	1270 ft. per min.
Load per in. width of face	1699 lb.
Total revolutions, gears	421,888
Average depth of wear 30T, 4/5-pitch, stub-tooth, 20-deg. involute pinion	0.00828 in.
Average depth of wear 30T, 4-pitch, standard-depth, 20-deg. involute pinion	0.00757 in.
Ratio of wear of 20-deg. stub-tooth pinion to 20-deg. standard pinion	1.09 to 1
Average depth of wear 60T, 4/5-pitch, stub-tooth, 20-deg. involute gear	0.00703 in.
Average depth of wear 60T, 4-pitch, standard-depth, 20-deg. involute gear	0.00587 in.
Ratio of wear of 20-deg. stub-tooth gear to 20-deg. standard gear	1.20 to 1

The load per inch width of face as indicated by spider deflection was 1307 lb.

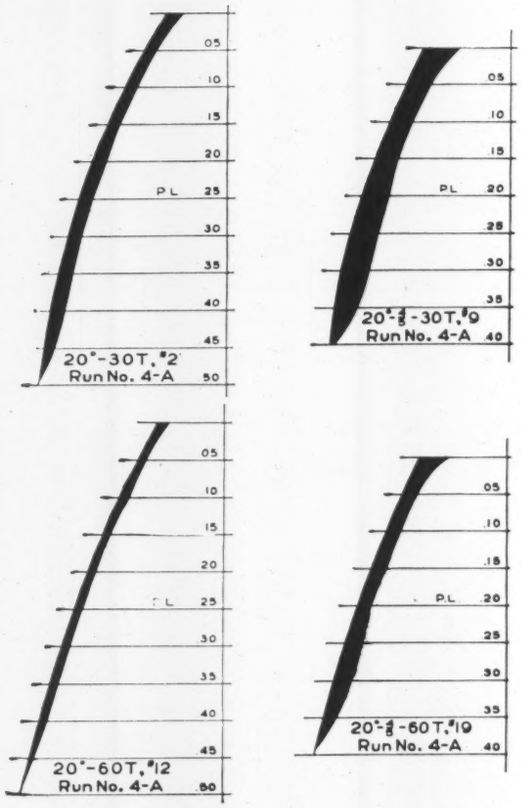


FIG. 8 AVERAGE ORIGINAL AND WORN FORMS OF THE FOUR SETS OF ENGAGING TEETH OF SERIES 5, RUN 4-A

Cast-iron gears furnished by Brown & Sharpe Mfg. Co. 30T and 60T, 4-pitch standard-depth, 20-deg. involute against 30T and 60T, 4/5-pitch, stub-tooth, 20-deg. involute. All gears 1½-in. width of face. Stub teeth next to spider.

Pitch speed	1270 ft. per min.
Load per in. width of face	2000 lb.
Total revolutions, gears	282,368
Average depth of wear 30T, 4/5-pitch, stub-tooth, 20-deg. involute pinion	0.0355 in.
Average depth of wear 30T, 4-pitch, standard-depth, 20-deg. inv. pinion	0.018 in.
Ratio of wear of 20-deg. stub-tooth pinion to 20-deg. standard-depth pinion	1.97 to 1
Average depth of wear 60T, 4/5-pitch, stub-tooth 20-deg. involute gear	0.0233 in.
Average depth of wear 60T, 4-pitch, standard-depth, 20-deg. involute gear	0.01145 in.
Ratio of wear 20-deg. stub-tooth gear to 20-deg. standard-depth gear	2.04 to 1

The load per inch width of face indicated by spider deflection was 1733 lb.

The grand average ratio of wear of the 20-deg. stub teeth to the 20-deg. standard-depth teeth (Series 4 and 5) was 1.62 to 1.

The Locomotive Testing Plant[1]

Early Stationary Tests and Testing Plants in Europe—Efficiency of Draft-Producing Action of the Exhaust—Reliable Data Obtainable from Road Tests—Influence of Purdue Plant on European Locomotive Design

BY A. I. LIPETZ,[2] SCHENECTADY, N. Y.

WE OUGHT to be very much indebted to Mr. L. H. Fry for his admirable paper which gives, in a very concise form, a complete synopsis of the work done by the American locomotive testing plants. I fully support his recommendation that the American Railway Locomotive Association build a locomotive testing plant to be devoted to scientific and impartial study of locomotive designs and devices. No doubt such a plant would be of greatest value to the proper development of locomotive designs in this country, and to the matter of selection of the best devices from the many on the market of railway supplies. It would help to save money wasted in trying various devices on locomotives in service.

However, I would like to make several remarks with respect to Mr. Fry's statements, and also take exception to his assertion that the constancy of conditions and accuracy of measurements on a testing plant give the tests on the latter a great advantage over road tests.

EARLY STATIONARY TESTS OF LOCOMOTIVES IN EUROPE

To Mr. Fry's statement that the locomotive testing plant is purely of America origin, I would like to add that as far back as 1881, Mr. Alexander Borodin, chief engineer of the Russian Southwestern Railway, tested locomotives in stationary condition in order to find out the advantages of compounding and steam jacketing.

[1] Discussion of a paper entitled The Locomotive Testing Plant and Its Influence on Steam-Locomotive Design, by Lawford H. Fry, presented at the Altoona Regional Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Altoona, Pa., October 5–7, 1925, and published in slightly abridged form in MECHANICAL ENGINEERING, November, 1925, pp. 881–886.

[2] Consulting Engineer, American Locomotive Company. Mem. A.S.M.E.

He blocked the engine in such a way as to raise the main driving wheels, which he used as pulleys. By means of belts the total output of the locomotive was utilized for driving the locomotive machine shops at Kiev. In such a way he proved by stationary tests that compounding offers a gain of about 15 to 20 per cent in fuel, whereas jacketing is of little value. His assistant, Mr. L. M. Loevy, repeated the tests on road engines, and confirmed Borodin's results. These tests were the beginning of the wide application of compounding to Russian locomotives, which lasted for approximately over 25 years—up to the time when superheating took its place.

While the Borodin tests were not carried out on exactly what could be called a stationary testing plant, the method of testing was the same as that later employed on the American testing plants, with the difference, however, that instead of wasting the work of the locomotive in water brakes, Borodin utilized the performance of locomotives in producing useful work. Therefore, while Mr. Fry's statement may be literally correct, I think that it requires an amendment in form of a reference to these first stationary locomotive tests. Mr. Fry is evidently familiar with Borodin's tests, as in Appendix No. 2 to his paper, in the Bibliography of Publications with Locomotive Testing Plants, he gives the title of Mr. Borodin's paper published in the Proceedings of the Institution of Mechanical Engineers, London, in 1886.[3]

Locomotive Testing Plants Abroad

As regards Mr. Fry's inability to find records of any real testing plants installed outside of the United States, I would like to mention that one testing plant was installed in 1904 in England at the Swindon locomotive shops of the Great Western Railway, which was described by G. J. Churchward in *The Engineer* (London),[4] and two were built in Russia: one at the Putiloff Locomotive Works and another at the Alexandrovsky railway shops, both in Petrograd. The Putiloff testing plant was completed in 1904, and a full description of it was published by its designer, Prof. M. V. Gololobov, in 1907.[5] The Alexandrovsky testing plant was built only recently. A third Russian locomotive testing plant, which had been built in Esslingen, Germany, was described last year in *The Engineer* (London).[6] The plant was used during 1924 for testing the 2-10-2 Russian 1200-hp. Diesel-electric locomotive in comparison with a 0-10-2 Russian steam locomotive. It has been since dismantled and shipped to Russia for installation as a permanent testing plant. Some particulars about the plant are also given by Prof. G. Lomonossoff in his book on the Diesel-electric locomotive.[7]

Efficiency of Draft-Producing Action of Exhaust

Mr. Fry states that it was shown at the Purdue plant that the draft-producing action of the exhaust steam was independent of the intermittency of the exhaust, the essential factor in the produced suction being the quantity of exhausted steam. He remarks further that this fact "is often overlooked, particularly when the claim is made that a multi-cylinder locomotive gives a more efficient exhaust action." Dr. Goss's tests at Purdue actually showed that the capacity of the steam jet through the exhaust nozzle as a means for producing draft is nearly proportional to the weight of steam discharged per unit of time,[8] and that with a given weight of steam discharged, whether in the heavy exhausts incident to slow speed or in the more rapid impulses which are sent forth at higher speeds, the draft is practically the same.[9] This would tend to indicate that the *average*[10] vacuum is not affected by the number of impulses, but this is not the claim which is usually made regarding multi-cylinder locomotives and, to be more specific, the three-cylinder locomotives. The claim is that the more frequent and consequently lighter exhausts give, at the same average vacuum, a more uniform draft, resulting in a better efficiency of the boiler, as indicated by the greater evaporation per pound of fuel. The reason is obvious and lies in the fact that the heavy individual impulses cause incomplete combustion and entail great cinder and spark losses, in accordance with other tests made by Dr. Goss, whereas the more numerous and lighter impulses, giving the same average draft action, do not cause any such losses. This fact has been known since the first two-cylinder compound locomotives were built in the early eighties. These locomotives—with only two exhausts per revolution—showed a lower boiler efficiency than the two-cylinder simple-expansion locomotives with four exhausts. Von Borries, the well-known authority on compound locomotives and their advocate, considered this fact as the most important disadvantage of the two-cylinder compound locomotives.[11] Tests made later in Russia fully confirmed the fact that two exhausts give a lower boiler efficiency than four.[12]

It is true that Dr. Goss also said that "variations in the character of the exhaust jet—such as result from changes in speed or cut-off—do not in themselves affect the efficiency of the boiler,"[13] but out of the 35 tests on which this statement was based, only three were made at a rate of combustion over 150 lb. per sq. ft. of grate area per hour, and the coal fired during the tests was of such quality that even at a very high rate of combustion, namely, 241 lb. per sq. ft. per hr., the spark losses amounted to only 15.5 per cent.[14] The results would have been different if lighter coal had been used.

The fact that four exhausts give a lower boiler efficiency than six has been proved in this country and in England with the three-cylinder locomotives, as can be seen from the official test figures of the 4-8-2 three-cylinder locomotive No. 5000 on the Lehigh Valley Railroad. The overall boiler efficiency was 77.58 per cent at an hourly dry-coal rate of firing of 69.3 lb. per sq. ft., of grate area, whereas at the same rate of firing the efficiencies obtained from tests with Pennsylvania Railroad locomotives at the Altoona testing plant never exceeded 72 per cent.

Likewise, tests with the 2-8-2 Missouri Pacific three-cylinder locomotive made at the Altoona testing plant give a boiler-efficiency curve which is higher than those of all the Pennsylvania locomotives tested at Altoona, except one class—the K4s (4-6-2 two-cylinder passenger) locomotives, which show an exceptionally good boiler performance, probably due to the use of the kind of fuel best suited to the actual boiler proportions.

The better efficiency of the boiler on three-cylinder locomotives is also illustrated by the fact that the economy in fuel on three-cylinder locomotives is very often higher than that in water; this can be explained by the more complete combustion and smaller cinder losses. Tests made on the London & North-Eastern Railway of England showed that on three-cylinder Atlantic-type locomotives the economy in fuel was 19 to 25 per cent, at the time when economy in water was only 10 to 18 per cent.[15]

As regards four-cylinder locomotives, there is no difference between them and two-cylinder locomotives, because with cranks at 90 and 180 deg., two exhausts always coincide in time, and the number of exhausts on two-cylinder and four-cylinder locomotives is the same.

Reliable Data Obtainable from Road Tests

The exception which I take to Mr. Fry's statement is the preference which he gives to stationary tests as compared with road tests. The essential part of the stationary test is the constancy of conditions, such as speed, cut-off, etc.; therefore, if we could test locomotives on the roads under constant conditions, there

[3] Even prior to that date, Mr. Borodin published a description of a locomotive testing plant in the *Organ fur die Fortschritte des Eisenbahnwesens*, 1881, nos. 4 and 5.

[4] December 22, 1905, p. 621.

[5] Bulletins of the St. Petersburg Institute of Technology (in Russian), vol. 18.

[6] November 14, 1924, pp. 553–554.

[7] Die Diesel-Elektrische Lokomotive, by Prof. G. Lomonossoff, Berlin, 1924, pp. 83–89.

[8] Locomotive Performance, by Dr. W. F. M. Goss, New York, 1907, p. 138.

[9] Ibid., p. 238.

[10] Ibid., p. 138, col. 38.

[11] Von Borries. Compound Lokomotiven. *Organ fur die Fortschritte des Eisenbahnwesens*, 1883, pp. 190–192.

[12] Lomonossoff. Tests with Freight Compound Locomotives made in 1898–1890 on Kharkoff-Nikolaieff Ry. Published (in Russian) in Kiev, 1907, p. 131.

[13] Locomotive Performance, by Dr. W. F. M. Goss, New York, 1907, p. 146.

[14] Ibid., p. 162.

[15] The Three-Cylinder High-Pressure Locomotive, by H. N. Gresley; advance copy of a paper read before the Institution of Mechanical Engineers, London, on July 7, 1925, p. 8. See also pp. 18 and 19 regarding the uniformity of draft as measured by a draft recorder of the Cambridge Instrument Co.

would be very little difference between such tests and those on the testing plant. Moreover an advantage would be gained because the locomotive would be tested with its tender, which usually is taken off for laboratory tests, and under actual conditions of running on a track where the vibrations of movements affect the efficiency of evaporation. Some roads have sufficiently long grades, or level tracks, which would offer the possibility of testing locomotives under constant conditions. For instance, there is on one road in this country a division of about 38 miles in length consisting practically of a uniform grade of 1.8 per cent and an adjacent division of a uniform grade of 2.2 per cent of almost the same length. A freight locomotive with a train could be tested at a uniform speed with constant cut-off and throttle opening, temperature, boiler pressure, etc. during a period of two to three hours on each division, and a passenger locomotive during the same period of time on both divisions together. This would be just as convenient as testing a locomotive at a stationary plant. If a dynamometer car were attached to the tender of the locomotive the total output of the locomotive could be registered just as accurately as on a testing plant, and weather conditions would have no influence, as the resistance due to temperatures and wind would be included in the readings of the dynamometer. As regards accuracy, there would be no difference between the readings in a dynamometer car and those on a stationary plant. Even gas analyses could be made and temperatures in the firebox and other parts of the boiler could be measured if the necessary apparatus and galvanometers with compensation devices were installed in the car. Tests of this kind are being performed in Europe as a matter of routine. In two countries, Russia and Germany, special test departments attached to the Central Railways Administration have been in existence for years. Practically every year since 1898 such tests have been going on in Russia. It is interesting to note that many of the results which were obtained on the Altoona testing plant had been either confirmed, or even preceded by the Russian tests. So, for instance, the length of tubes in freight and passenger locomotives built in Russia since 1901 was made 4660 mm. at 46 mm. inside diameter (2-in. tubes); this would give a ratio of 101—in striking conformity with Bulletin No. 21 of the Pennsylvania Testing Plant published in 1913, which recommends a ratio of 102. It has been customary in western Europe and in Russia to design superheated locomotives with cut-offs less than 50 per cent, this on account of results of road tests made in the first decade of the present century. The difference between this practice and that of the Pennsylvania Railroad is that in the European locomotives the 85 per cent cut-off for starting is being obtained by the ordinary Walschaerts gear, whereas in the Pennsylvania 50 per cent cut-off Decapods special provisions are made in the valves for starting. Any attempt on the part of the engineer on a Russian superheated locomotive to use cut-offs running over 50 per cent would result in slipping of the driving wheels. The relation between water consumption per horsepower, cut-offs, and speeds was fully established for all Russian compound and simple-expansion locomotives, and the most economical combinations of the throttle opening and cut-offs were studied, especially for compound locomotives, where they are more important than for locomotives with simple expansion.

In order to check up whether the road-test figures are of real practical use, the following method has been employed in Russia. From the tractive-effort curves a very exact graphical speed-distance chart is drawn for a train of a certain tonnage. The most economical combinations of throttle opening and cut-off are chosen for each portion of track in accordance with speed. Further, the elements of work due to resistance and acceleration are calculated for the same portions of track (also graphically), and the consumption of fuel and water is thus ascertained. Then a test is made for which the driver is instructed to employ certain combinations, and a verification of speed, fuel, and water consumption is made. The actual figures do not differ usually by more than 3 to 5 per cent.

Even the fact that the firebox volume must be considered in addition to the firebox heating surface and the grate area, is known to European locomotive designers. I would mention here that the reason for the high location of boilers on some European locomotives, where the diameter of the boiler barrel does not require such high location, is due mostly to the desire to give the firebox the proper depth and volume.

I have no intention of criticizing Mr. Fry's paper or contesting his conclusions in so far as they refer to the testing plants, but I wish to correct the impression which one might obtain from the second paragraph of the paper, as printed in MECHANICAL ENGINEERING,[16] that laboratory tests are the only means of studying locomotive performance. Many roads that are unfortunate in having long grades, or fortunate in having long level stretches, can obtain as reliable data from road tests as one can get on a locomotive testing plant. Of course, it must be remembered that road tests made on a division with variable profile are very misleading. Average figures can have only comparative value with locomotives tested on the same division. If the relations between variables of locomotive performance could be represented by straight lines, this method might have been correct, but owing to the fact that curves of fuel and steam consumption per unit of work, of draft in the smokebox, etc. have a maximum (or minimum) about the average abscissas, the average figure from a test made on a variable profile has no meaning.

I would like to say in conclusion a few words regarding Mr. Fry's statement that the American testing plants materially influence locomotive design abroad. This statement is especially correct with respect to the Purdue plant, which exerted a tremendous influence on European locomotive design as reflected in European locomotive literature where references to Dr. Goss's tests abound.

MR. FRY'S REPLY TO MR. LIPETZ' DISCUSSION

Mr. Lipetz questions four statements made in the paper:

1 That the locomotive testing plant is of purely American origin. This statement was made with full knowledge that Borodin in 1881 had jacked up locomotives, fitted belts to the driving wheels, and made tests under these conditions. This ingenious but crude method enabled certain tests to be made, but the arrangement could hardly be called a locomotive testing plant. The plant at Purdue was the first to embody the principles which have been so fruitful in the production of knowledge, and we have Dr. Goss's statement that the Purdue plant was installed before he had any knowledge of Borodin's work.

2 That no real testing plants have been installed outside of the United States. It is true that a set of testing rolls was installed at Swindon. The record of work done on these rolls, however, is not sufficient to justify their being described as a real locomotive testing plant. The three Russian plants were overlooked. Thanks are due to Mr. Lipetz for completing the record.

3 That the efficiency of the draft-producing action of the exhaust is independent of its intermittency. This question can be settled more easily and much more definitely than by examining the various comparative tests quoted by Mr. Lipetz. In any series of tests made with a given boiler it will be found that for a given quantity of steam produced and exhausted the boiler efficiency will be the same whether the steam be exhausted at 40 r.p.m. or at 140 r.p.m. That is to say, the boiler efficiency is determined by the rate at which steam is produced and exhausted, and is not affected by the intermittency of the exhaust.

4 That tests can be made on a locomotive testing plant better than on the road. To any one at all familiar with the details of locomotive testing Mr. Lipetz' objection to this statement will be surprising, and a refutation will seem unnecessary. Very few railroads have a conveniently situated track on which it would be possible to run an hour's test at 60 miles per hour at absolutely uniform speed and cut-off. In a road test it is practically impossible to arrange in advance the exact speed and cut-off at which a test shall be run. With the cut-off determined, the speed will be determined by the equipment available and the atmospheric conditions. This makes it difficult to duplicate exactly any given road test. When in addition the convenience of working with instruments stationary and in close proximity to laboratory and computing room is considered, it seems to the author that for accuracy and convenience, tests on a locomotive testing plant are far ahead of road tests of locomotives.

---

[16] November, 1925, p. 881.

Recent Developments at Colfax Station

Results of Tests of the 3-A Element Recently Installed in This Station of the Duquesne Light Co., Showing Net Heat Rates of 12,750 B.t.u. per Kw-Hr. at 30,333 Kw., 13,021 B.t.u. per Kw-Hr. at 22,400 Kw., and 14,200 B.t.u. per Kw-Hr. at 15,050 Kw.

By CHARLES W. E. CLARKE,[1] NEW YORK, N. Y.

THE original installation at Colfax Station was put in operation on December 18, 1920, and consisted of one 60,000-kw. 3-element turbo-generator unit, equipped with 100,000 sq. ft. of condensing surface in four shells, with Le Blanc air pumps. The boiler equipment consisted of seven cross-drum boilers, each 51 tubes wide and 18 tubes high, with superimposed superheaters, fired by 17-retort, 22-tuyere underfeed stokers with double-roll clinker grinders. The operating pressure was 275 lb. per sq. in. and the total temperature 600 deg. fahr. A complete description was given in a paper presented to the Society at the Annual Meeting of 1921.[2]

The second 60,000-kw. unit was practically a duplicate of the first unit, with the exception that steam-jet air pumps were provided in connection with the condensing equipment and six boilers, 20-tubes high, were installed instead of the seven 18-tube-high boilers of the first installation. Superheaters were of the interdeck type. This extension was placed in operation October 21, 1922, and was described in a paper presented at the Annual Meeting of the Society in December, 1923.[3]

At the time of the third-unit extension in 1923, the questions of higher pressures and temperatures, pulverized fuel versus stoker firing, preheated air, multi-stage bleeding, and steam reheating at a middle point of the turbine were all discussed. It was decided to maintain the same operating pressure, increase the temperature to 650 deg. fahr., adopt pulverized-fuel firing in place of stokers and install 4-stage bleeding in connection with an auxiliary generator attached to the main-turbine shaft as a method of heat balance. It was also decided to install two turbine units in place of one larger unit.

The third-unit extension as now constructed consists of enlarging the present turbine and electrical bays sufficiently to house two 35,000-kw. multiple-exhaust turbines, together with the transformers and bus and electrical connections necessary for these two units, and increasing the boiler house to take five boilers.

One 22,914-sq. ft. stoker-fired boiler, similar to those furnished with the second unit, was installed to fill in a vacant space in this section of the boiler house, and five 27,680-sq. ft. pulverized-fuel-fired boilers were installed in the third-unit extension. These latter boilers are 47 tubes wide by 20 tubes high, with 24-ft. tubes and are equipped with fourteen burners per boiler, set in two batteries of seven each. The drums are set five feet higher than those of the first and second units in order to provide increased combustion space. The superheaters are of the interdeck type. These boilers were made 47 tubes wide in order to provide room to carry the preheater air ducts down the side of the boiler walls and still maintain the same column centers as exist on the original installations.

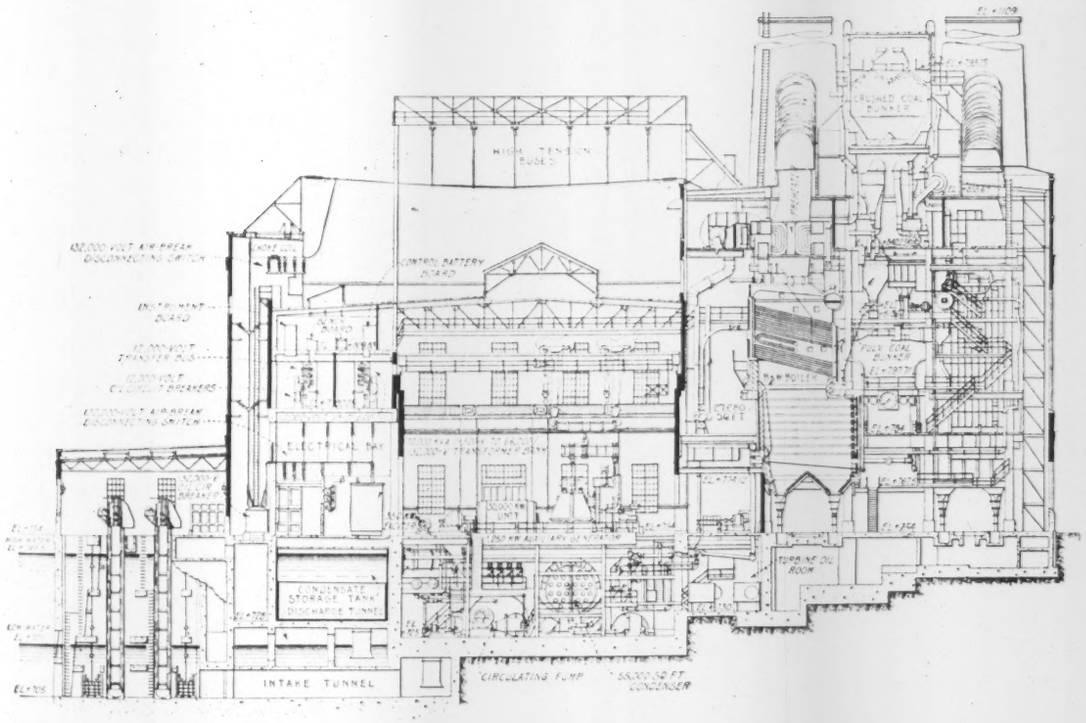


FIG. 1 CROSS-SECTION OF THE THIRD-UNIT EXTENSION, COLFAX STATION

The pulverizing and fuel feeding equipment is compactly arranged above the aisle between the two rows of boilers. Two six-ton mills are installed with each boiler. These are located on the top floor of the boiler house directly under the raw-coal bunker and at an elevation 16.25 ft. above the boiler drums; the separators are above the mills and the mill and separator room is completely walled off to isolate it from the remainder of the boiler house.

Pulverized-coal bunkers of 35 tons capacity are installed in front of each boiler above the drum line, and these supply fuel directly to the fourteen burner feeders attached to the boiler. The bunkers are fed through a duplicate set of screw conveyors, cross-connected so that any bunker may be fed from any set of mills on either side of the house. It will be noted that except for the short rise from the mills to the separator, the fuel has a continuous downward passage from the raw-coal bunker to the furnace; thus minimizing re-elevation of the fuel. This plan also reduces to a minimum the floor space required for boiler-room equipment, and results in a reduced cost of building construction as well as in economy of operation.

The air preheaters are of the plate type and are located above the boilers at the same elevation as the pulverizing mills. The

[1] Dwight P. Robinson & Co. Mem. A.S.M.E.

[2] Heat Balance of Colfax Station, Trans. A.S.M.E., vol. 43 (1921), p. 487.

[3] Boiler Test Results with Preheated Air, Colfax Station, Duquesne Light Co., Trans. A.S.M.E., vol. 45 (1923), p. 567.

Contributed by the Power Division and presented at the Annual Meeting, New York, November 30 to December 4, 1925, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Abridged. All papers are subject to revision.

preheater fans are located on the same elevation but in separate rooms, so arranged with doors and shutters that air may be taken from outside or inside the boiler room as may be required for ventilation purposes. The fans force air through the preheaters, air ducts, and furnace walls and deliver the air to the combustion space of the furnace at about zero pressure.

Two of the boilers have furnaces constructed with hollow side and front walls through which the preheated air passes before it enters the furnace. The rear walls of these furnaces are protected by plain-tube water screens. These boilers have been in operation since October, 1924, and the furnaces are in good condition. It has been found, however, that with CO_2 higher than 13 per cent, the furnace walls will slag and run. The operation of these boilers was discussed by the author at the Milwaukee meeting of the Society in the spring of 1925. The other three boilers have furnaces constructed with fin-type water screens on the side, plain tubes on the rear walls, and hollow front walls. They have been in operation since July, 1925, and the indications are that a considerably higher CO_2 can be maintained without appreciable slagging. Fin-type coolers are now being installed in the side and rear walls of the first two boilers.

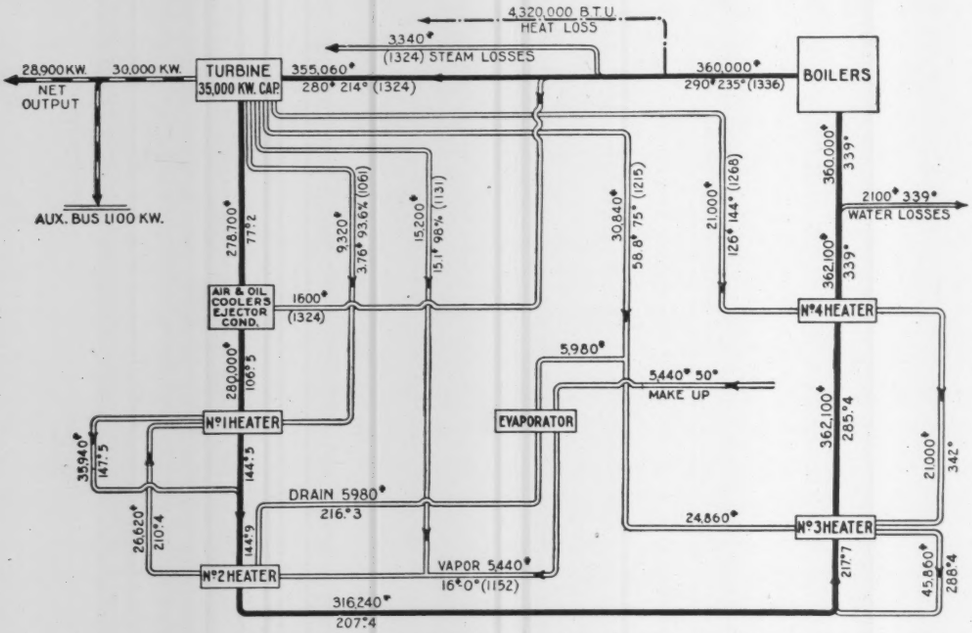


FIG. 2 HEAT-BALANCE SYSTEM, THIRD-UNIT EXTENSION, COLFAX STATION

All of the furnaces have water screens across the ashpits which are constructed with hollow-lined bottoms and are air-cooled. Clinker and ash are dumped from the pits into sluiceways which run lengthwise of the boiler house and discharge into transverse receiving pits, from which the ash is removed by a clam-shell bucket and delivered directly to distributing cars or trucks.

The two turbo-generators which comprise the third-unit installation are placed crosswise in the turbine room with a house generator attached to the generator end of each machine. They cover approximately the same space as each of the No. 1 and No. 2 triple units. All auxiliaries are electrically driven except the air pumps, which are of the steam-jet type. Electrically driven auxiliaries are essential for realizing the full advantage of main turbine bleeding for heating boiler feedwater. The principal auxiliaries of the main unit are normally carried by the house generators, but they are also controlled by a device known as a "voltage chaser" which automatically throws over from the house-generator bus to the station-house bus, or vice versa, in case of the loss of voltage in either. This system has proved of great value in preventing a station outage when such loss of voltage has occurred.

With all units down, the station can be started from outside power, or in extreme emergency, with the outside power off, the house turbines installed with Nos. 1 and 2 may be used for starting up.

Condensate is normally used as a cooling medium for the generator air coolers, transformers, and turbine-bearing oil, and to condense the steam from the steam-jet vacuum pump; the condensate flows from the hot well through the equipment in the order named. Under full-load conditions about 29 deg. fahr. is added to the condensate due to losses recovered. This, however, is not a net thermal recovery, as the reduction in steam extracted for the bleeder heaters reduces their efficiency about an equal amount. The advantage in using this cycle lies in the saving in the maintenance of the coolers and in the possibility of an even rate of heat transfer due to the clean water; also in the preclusion of chance of an outage due to clogging by leaves or by the scum which prevails at times in the available raw-water supply. For emergency conditions a separate generator-air cooler section was installed for raw water. Up to the present time this emergency cooler has not been required for operation. The transformers operate on a water-to-water heat-exchanger system arranged so that raw water may be used as a cooling medium in emergency, without passing raw water through the transformer coils. The turbine-bearing-oil coolers are also provided with an emergency connection for the same purpose.

The boiler-feed pumps for the third-unit installation are driven by 500-hp., 50 deg. continuous rating, 2200-volt, 3-phase, 60-cycle, 1800 to 1630 r.p.m. variable-speed, Westinghouse motors with type "CW" rotor windings. The interesting feature of the installation is the new type of motor control used.

The control for each motor consists of a Hagan automatic pressure regulator in which a balanced piston is actuated by changes in the difference between the boiler-feedwater pressure and the steam pressure.

The piston rod of this regulator is attached to a rack actuating a gear which in turn operates a notching drum. The notching drum closes a circuit which operates a pilot motor driving the main controller a given distance until a releasing device opens the motor circuit. In case the piston movement of the pressure regulator continues, the pilot motor continues to notch ahead until the increased speed of the motor causes sufficient pressure to build up to bring the regulator to rest.

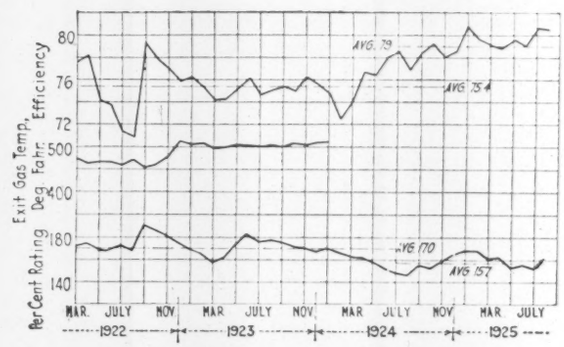


FIG. 3 OVERALL BOILER-ROOM OPERATING RESULTS, JANUARY, 1922, TO AUGUST, 1925, COLFAX STATION

The controller consists of a slate panel on which are mounted the necessary protective relays, the pressure regulator, a hand-wheel controlling the motor starting resistance, and six push buttons. Two push buttons, "start" and "stop," close or open the oil circuit breaker in the motor primary circuit. Two push buttons, "fast" and "slow," control the change in speed of the boiler-feed-pump motor when the automatic pressure regulator

is not in use; and two push buttons, "automatic" and "manual," change the control from the regulator to manual control. With this scheme it is possible to operate this equipment at any given speed or to switch to automatic speed control. These pumps normally operate as part of the third-unit heat-balance system, drawing water from the low-pressure heater and discharging through the high-pressure heaters into the common feed system of the station. In an emergency, however, they may draw their supply from the boiler feed supply of units Nos. 1 and 2.

The third-unit extension required additional intake capacity, and a screen house of sufficient capacity to take care of the third and fourth extensions has been constructed. Owing to the heavy deposits of water-soaked leaves which occur during the late fall and early spring, it was found advisable to increase the screen protection, and the new intake has been equipped with two rows of screens, the front row having $1^1/_2$-in. mesh and the rear row $^3/_8$-in. mesh. This affords a double protection in the event that the front row becomes overloaded and fails. The discharge tunnel is a continuation of the Nos. 1 and 2 units tunnel.

Fig. 1 is a cross-section of the third-unit extension and shows in detail the arrangement of the station.

Fig. 2 shows in detail the heat-balance system.

Boiler-Room Operating Results

The boiler-room operating results of the first unit were covered by the author in a paper entitled Boiler-Room Performance and Practice at Colfax Station,[4] presented to the Society at the Annual Meeting of December, 1922. These in general, in so far as applies to the stoker-fired equipment, have been maintained practically the same. Fig. 3 gives the overall operating results from January, 1922, to August, 1925. The average exit gas temperatures are not given after the installation of preheaters because temperature readings on the preheater boilers are now taken above the preheater and the comparison is of no use.

The availability of all boilers for the period from January 1, 1921, to July 1, 1925, averages 90 per cent. The unavailable period (10 per cent) is the time required for cleaning, repairs, and alterations. During this period forty-three tubes have been replaced; thirty-six of these were removed for test purposes to determine the extent and ascertain the cause of corrosion which was taking place. The results of these observations will be given to the Society at a later date. Four tubes have been removed due to cutting from soot-blower elements and three due to small cracks and holes which developed in the tubes.

TABLE 1 TEST OF 3-A ELEMENT, APRIL 24, 25, 1925, AT COLFAX STATION, AVERAGED READINGS

Date	April 25, 1925	April 25, 1925	April 24, 1925
Time	1 p. m. to 4 p. m.	9 a. m. to 12 a. m.	1.30 p. m. to 4.30 p. m.
Duration, hr.	3	3	3
Load, total, ind. kw	15,371	22,964	30,444
Load, main gen., ind. kw	14,967	22,552	30,016
Load, aux. gen., ind. kw	404	412	428
Load, total, int. kw	15,850	23,400	31,433
Load, main gen., int. kw	15,450	23,000	31,033
Load, aux. gen., int. kw	400	400	400
Power factor, per cent	69.0	82.0	87.3
Frequency, cycles	60.9	60.7	60.9
Voltage	11,967	12,040	11,970
Amperes A	1,031	1,298	1,637
" B	1,017	1,295	1,636
" C	1,020	1,275	1,620
Vacuum board, in. Hg	28.35	28.25	28.15
Back-pressure board, in. Hg. abs.	0.92	1.04	1.17
Vacuum, cellar, in. Hg	28.53	28.55	28.52
Back pressure, cellar, in. Hg. abs.	0.74	0.74	0.80
Absolute pressure gauge, in. Hg. abs.	0.90	0.96	1.15
Exhaust temperature, deg. fahr.	77.8	79.1	85.2
Corresponding back pressure, in. Hg. abs.	0.99	1.00	1.22
Hotwell temperature, deg. fahr.	76.	77.	83.3
Barometer reading, in. Hg	29.269	29.289	29.321
Barometer temperature, deg. fahr.	80.3	76.7	86.7
Hotwell discharge, ind., lb. per hr.	161,000	216,300	292,000
" " int., lb. per hr.	162,667	217,600	294,000
Water to No. 1 heater, ind., lb. per hr.	162,000	217,400	295,000
" " " " int., lb. per hr.	160,667	216,000	294,000
High pressure drains, ind., lb. per hr.	20,300	32,700	52,400
" " " int., lb. per hr.	20,333	32,300	49,000
Low pressure drains, ind., lb. per hr.	20,800	27,700	40,700
" " " int., lb. per hr.	22,333	31,700	42,700
Water to boilers, ind., lb. per hr.	204,000	272,800	370,500
" " " int., lb. per hr.	201,000	266,600	361,666
" " " chart, lb. per hr.	205,000	271,000	371,900
Line steam temperature, deg. fahr.	566.	598.	591.7
Throttle pressure, lb. per sq. in.	270	267	266
Primary pressure, lb. per sq. in.	181	254	265
Secondary pressure, lb. per sq. in.	62	90	240
Tertiary pressure, lb. per sq. in.	50	80	127
Heater No. 1 vacuum heater in. Hg.	24.8	23.4	21.2
" " 2 vacuum heater in. Hg.	12.3	5.4	2.2
" " 3 pressure heater in. Hg.	20.0	31.9	50.3
" " 4 pressure heater in. Hg.	55.0	81.3	123.0
Water to evap., ind. lb. per hr.	7,300	6,950	6,670
Water to evap., int. lb. per hr.	7,333	6,700	6,170
Evap. raw water in, temp., deg. fahr.	67.2	66.0	64.4
Inlet steam press. to evap., lb. per sq. in.	15.	19.2	28.9
Inlet steam temp. to evap., deg. fahr.	291.0	319.0	356.7
Evap. vapor vacuum, in. Hg	2.0	0.0 lb. per sq. in.	4.5
Evap. vapor temp., deg. fahr.	185.0	200.4	215.0
Evap. drain temp., deg. fahr.	213.0	216.3	230.3
Drain temp. heater No. 1, deg. fahr.	126.0	138.0	151.6
" " " " 2, deg. fahr.	175.0	190.3	208.0
" " " " 3, deg. fahr.	252.0	269.0	288.3
" " " " 4, deg. fahr.	256.0	278.0	300.7
" " " " 3, after cooler, d.fahr.	250.0	266.1	284.7
Steam temp., heater No. 1, deg. fahr.	129.0	141.2	153.2
" " " " 2, deg. fahr.	208.0	220.7	236.4
" " " " 3, deg. fahr.	291.0	323.9	370.0
" " " " 4, deg. fahr.	385.0	422.0	501.5
Cond. temp. out of heater No. 1, deg. fahr.	118.0	140.2	152.7
" " " " " " 2, deg. fahr.	184.0	198.0	213.4
" " " " " " 3, deg. fahr.	253.0	273.1	294.2
" " " " " " 4, deg. fahr.	303.0	325.0	348.9
" " in heater No. 2, deg. fahr.	127.0	143.8	155.0
" " " " " 3, deg. fahr.	210.0	214.0	221.3
Air ejector steam pressure, lb per sq. in.	215.0	214.0	211.0
" " steam temp., deg. fahr.	535.0	568.4	559.8
" " cond. temp., in, deg. fahr.	96.0	94.0	96.0
" " cond. temp., out, deg. fahr.	110.0	104.2	104.1
" " raw water in, deg. fahr.	65.0	64.7	64.0
" " raw water out, deg. fahr.	68.0	66.2	66.9
" " primary drains temp., deg. fahr.	110.0	105.3	100.0
" " secondary drains temp., deg. fahr.	122.0	118.0	116.0
" " air discharge, cu. ft. per min.	13.8	8.0	5.9
" " secondary drains, lb. per hr.	1,528	1,362	1,380
Oil coolers water in, temp., deg. fahr.	91.7	90.2	93.5
" " water out, temp., deg. fahr.	96.0	93.9	96.0
" " oil in, temp., deg. fahr.	141.0	139.2	142.0
" " oil out, temp., deg. fahr.	112.0	109.0	111.6
Circulating water in, temp., deg. fahr.	62.0	61.1	58.6
" water out, temp., deg. fahr.	68.7	70.0	70.7
" pump disch. press., lb. per sq. in.	3.8	3.8	5.0
" pump suction press., in. Hg.	1.8	1.8	1.5
" pump r.p.m.	298.	297.3	298.
Mason regulator pressure, lb. per sq. in.	68.3	66.4	72.0
G. R. coolers raw water in, temp., deg. fahr.	62.0	61.1	58.7
" " raw water out, temp., deg. fahr.	66.	65.9	63.0
" " transformer cooling water in, temp., deg. fahr.	91.9	92.7	86.0
" " transformer cooling water out, temp., deg. fahr.	64.0	62.2	61.1
U-fin air coolers, air in, temp., deg. fahr.	131.0	135.0	143.0
" " " air out, temp., deg. fahr.	88.0	89.0	94.0
" " " cond. in, temp., deg. fahr.	76.7	78.0	84.0
" " " cond. out, temp., deg. fahr.	92.0	90.1	94.0
Gland water leak off, lb. per hr.	3,773	4,049	4,463
Gland water leak 2, temp., deg. fahr.	110	118	149
Governor oil pressure, lb. per sq. in.	50.8	50.9	50.5
Bearing oil pressure, lb. per sq. in.	6.9	6.8	6.5
Thrust bearing oil pressure, lb. per sq. in.	4.3	4.3	4.2
Thrust bearing oil temp., deg. fahr.	124	122	125
Bearing oil No. 1, deg. fahr.	133	133	134
" " Nos. 2 and 3 temp., deg. fahr.	154	153	154
" " No. 4 temp., deg. fahr.	142	139	143
" " No. 5 temp., deg. fahr.	112	108	114
Bearing oil to bearings temp., deg. fahr.	111	110	111.6
Hotwell pump discharge press., lb. per sq. in.	42.0	45.1	52.9
H. P. drain pump discharge press.,[1] lb. per sq. in.	32.0	36.0	28.0
L. P. drain pump discharge press.,[1] lb. per sq. in.	30.5	31.5	39.5
Gland water press., lb. per sq. in.	8.0	8.0	8.0
Turbine r.p.m.	1820	1820	1840

[1] This pressure was reduced for test period by speeding up boiler feed pump in order to make these pumps handle the water.

Turbine-Room Operating Results

The overall operating results of the entire station from January, 1922, to August, 1925, are shown in Fig. 4. The high heat rate from May to September, 1922, was due to a coal strike which made it necessary to burn coals of widely different grades and characteristics. During the period of January, February, and April of 1923 and January and February of 1924, the units were operated with one or more of the elements out of service. This materially increases the heat rate of the turbine, the water rate rising from 11 to 18 or 20 lb. for such operation. The yearly average curve shows the effect of the installation of preheaters, pulverized-fuel system, and four-stage bleeding, which started in 1924 and was completed in 1925. As at present arranged, precise determination cannot be made of the heat consumption of the complete third-unit installation by itself. Tests have been made, however, which show the heat rate at the boiler nozzle to be 12,752 B.t.u. per net kw-hr. delivered at full load, 13,021 B.t.u. per net kw-hr. delivered at three-quarters load, and 14,200 B.t.u. per net kw-hr. delivered at half load. The results of these tests are given in detail in Table 1.

As bearing upon an opinion more or less current that modern steam turbines and boilers of unusually large capacity are un-

[4] Trans. A.S.M.E., vol. 44 (1922), p. 217.

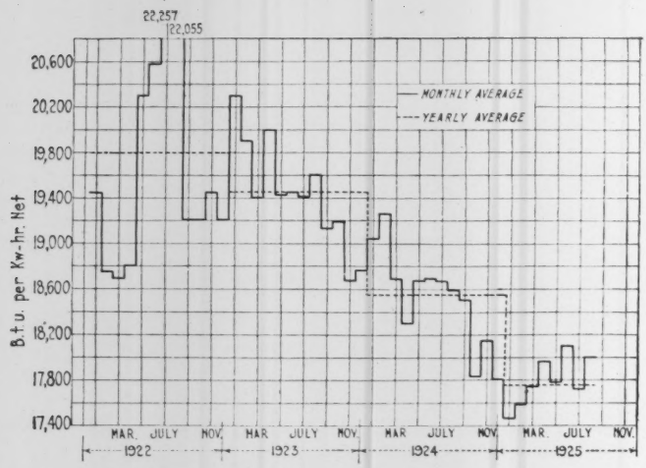


FIG. 4 OVERALL TURBINE-ROOM OPERATING RESULTS, JANUARY, 1922, TO AUGUST, 1925, COLFAX STATION

reliable, a special study has been made to show time availability and outages on the units installed in Colfax Station.

The first three-element turbine has been installed since December, 1920, and up to July, 1925, has been available wholly or partially for 93 per cent of the time and as a complete unit 70 per cent of the time. The principal cause of the outages has been blade and dummy rubbing; the total outage due to this cause has been 1587 hours for the period. The remainder of the outage time has been for various minor repairs and changes.

The second three-element unit was installed in October, 1922, and up to July, 1925, has been available wholly or partially for

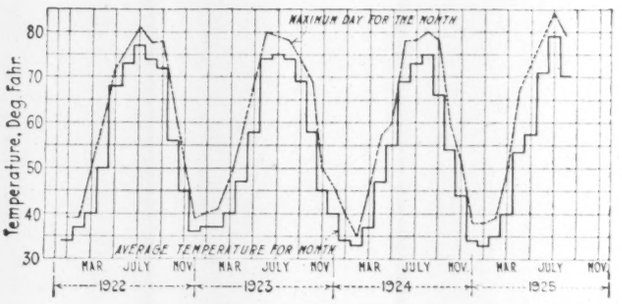


FIG. 6 MAXIMUM AND AVERAGE MONTHLY TEMPERATURES OF CONDENSING WATER, COLFAX STATION

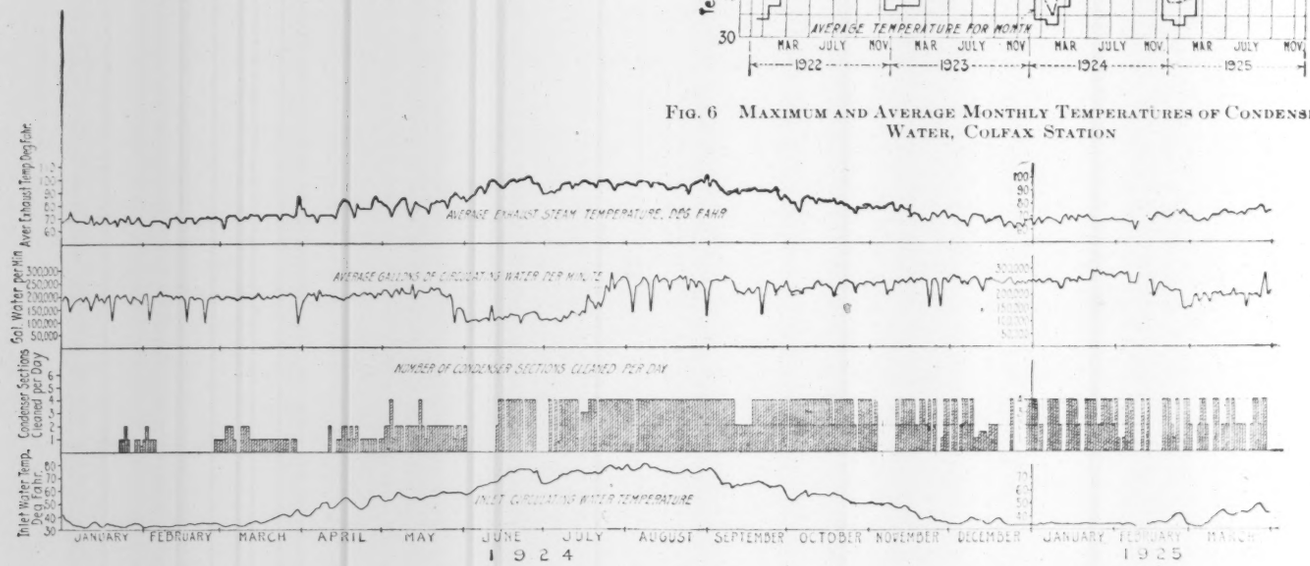

Aver Exhaust Temp Deg Fahr
AVERAGE EXHAUST STEAM TEMPERATURE, DEG FAHR
Tot Water per Min
AVERAGE GALLONS OF CIRCULATING WATER PER MIN.
Condenser Sections Cleaned per Day
NUMBER OF CONDENSER SECTIONS CLEANED PER DAY
Inlet Water Temp. Deg Fahr
INLET CIRCULATING WATER TEMPERATURE
JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER JANUARY FEBRUARY MARCH
1924
1925

FIG. 5 FREQUENCY AND EFFECTIVENESS OF CONDENSER CLEANING OPERATION, COLFAX STATION

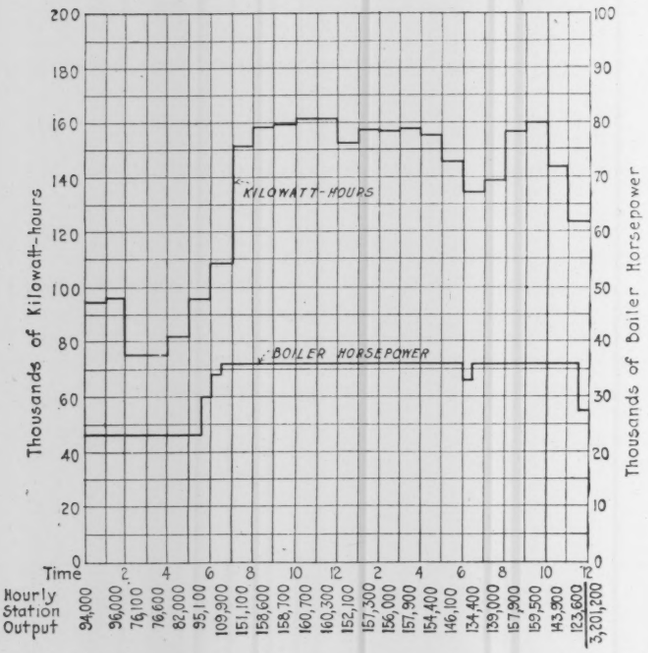


FIG. 7 TYPICAL DAILY LOAD CURVE, TUESDAY, SEPTEMBER 15, 1925, COLFAX STATION

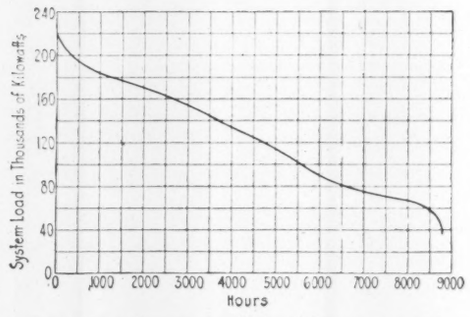


FIG. 8 LOAD-DURATION CURVE FOR ENTIRE DUQUESNE LIGHT COMPANY SYSTEM FOR THE YEAR 1924

85.5 per cent of the time and as a complete unit for 82 per cent of the time. It has been out for repairs and alterations 1788 hours, or 7.5 per cent of the time, the principal cause of the outage on this machine being blade and dummy trouble. The total outage due to this cause has been 950 hours. The remainder of time out was for minor repairs and changes.

The third-unit installation has been in service less than a year. The first unit of this installation has been available 86 per cent of the time. It has been out for inspection and repairs 928 hours. The second part of the installation has been available 92 per cent of the time and out for inspection and minor changes 111 hours.

As previously mentioned, considerable difficulty has been encountered at this location on account of scum in the river, especially

in the summer time, which has made it necessary to clean the condensers very frequently. In order to facilitate this operation all condenser shells are equipped with arrangements for pumping the water from the water section overboard, so as to prevent water and debris from being deposited on the basement floor when the condensers are opened. Fig. 5 shows the frequency and effectiveness of the cleaning operation.

Fig. 6 shows the maximum and the average monthly temperatures of condensing water prevailing for the past four years. It will be noted that there has been a gradual rise in the temperature during the summer months, and that a mean of 84 deg. fahr. was reached during July of this year.

Costs

The proper objective in power-station design is the lowest cost of electric energy inclusive of fixed charges as well as operating expenses. If this objective is followed, it is reasonable to expect differences in investment in different localities. Investment may also be influenced considerably by the physical conditions to be met at different sites, such as foundation difficulties, length for intake or discharge tunnels, etc. Moreover, there is divergence of practice in just what is included in or omitted from the total cost figures which are published and discussed.

These various influences doubtlessly explain a part of the very wide differences in costs discussed at the present time, varying from seventy dollars to more than two hundred dollars per kilowatt. They do not, however, explain all the differences, since the capabilities of the designers and the builder are important factors in the final cost.

The totals given below include all costs for the power station, sea wall, intake and discharge tunnels, outside switching station, and all overhead costs, such as engineering and construction fees.

The cost of the Colfax Station at the completion of the second unit was $13,982,321.81, or $116.51 per kw. for an installed capacity of 120,000 kw. The third-unit installation, of 70,000-kw. capacity, cost $8,019,483, making a total cost to date of $22,001,804.81, or $115.80 per kw. for an installed capacity of 190,000 kw. This cost includes building, foundations, reserve boilers, and service equipment which are applicable to the fourth unit.

TABLE 2 DISTRIBUTION OF COSTS, COLFAX STATION, CAPACITY 190,000 KW.

	Per cent
Boiler plant	16.1
Draft system	4.9
Feedwater system	1.3
Condensing-water system	4.1
Condenser and auxiliaries	6.8
Piping	6.9
Coal handling	1.3
Turbine and generators	15.9
Auxiliary equipment	1.9
Switchboards, transformers, conduit, and wiring	14.4
Outdoor switching station	0.7
Preliminary operations	0.6
Sea wall and shore protection	0.9
Station yard and tracks	1.7
Building and foundations	20.1
Service equipment	1.7
Machinery foundations	0.7
	100.0

At the present time the Duquesne Light Company have under way the installation of a fourth unit of 80,000 kw. capacity at an estimated cost of $7,025,000, which would give a total installed capacity of 170,000 kw. at a total cost of $29,026,804, or $107.50 per kw. These figures are exclusive of an outside coal-handling plant and a coal railway to the mine, constructed at a total cost of $422,100.32. It will be noted that the unit cost decreases as plant additions are made due to the necessity of constructing building and installing equipment which also serve the future additions.

Table 2 gives the percentage costs of the various elements of the 190,000-kw. development.

Fig. 7 shows a typical daily load curve and boiler-capacity curve.

Fig. 8 gives the load-duration curve for the entire Duquesne Light Company system for the year 1924.

Survey of Results

The test results indicate the following performance:

Output (net), kw	30,333	22,400	15,050
Heat rate (net), B.t.u. per kw-hr	12,752	13,021	14,200
Water rate (net), lb. per kw-hr	12.84	12.63	13.63
Line steam pressure, lb. per sq. in	266	267	270
Line steam superheat, deg. fahr	180	186	153
Exhaust pressure, in. Hg	1.22	1.00	0.99
Steam from bleeder No. 1, lb. per hr	12,666	6,556	322
Steam from bleeder No. 2, lb. per hr	14,344	7,380	4,108
Steam from bleeder No. 3, lb. per hr	35,013	24,065	17,230
Steam from bleeder No. 4, lb. per hr	20,207	14,193	10,270
Total steam bled, lb. per hr	82,230	52,194	31,930

Higher Steam Pressures in the Industrial Plant

By WILLIAM F. RYAN,[1] SYRACUSE, N. Y.

This paper shows that the gains from high pressure are greater in the industrial plant than in the central station, and that except for the question of suitable feedwater for high-pressure boilers, the problems involved are less difficult. The relative cost of power for varying initial pressure is estimated. The relative efficiency of turbine and engine prime movers, and the application of higher pressures to manufacturing equipment, are discussed. It is indicated that pressures up to the present commercial limit, about 1200 lb. per sq. in., may be used advantageously in the industrial plant which has a high load factor, and in which the demand for power is high, in proportion to the demand for process steam.

THE value of steam pressures higher than 400 lb. per sq. in. in the central station is a debatable subject; at least it is still being debated. There can be little question, however, that higher pressures can be used to advantage in industrial plants which use steam for manufacturing purposes.

The increase in thermal efficiency obtained by using pressures higher than 400 lb. per sq. in. in the condensing plant can hardly exceed 20 per cent. In the industrial plant the gain may be 75 per cent or greater if the use of higher initial pressure permits the substitution of non-condensing prime movers—whose exhaust steam is used in process—for condensing units.

The application of higher pressures to large condensing units has been discussed at length in the Transactions of the Society. It is the purpose of this paper to initiate a discussion of the same problem as it affects the industrial plant.

The opportunity for generating cheap power, in the average industrial plant, is limited. If steam is used in process, or for heating, power may be generated very cheaply, but only to the extent that the exhaust from the prime movers can be utilized. Many plants which use no process steam are compelled to generate their own power on account of the high cost or low reliability of public-service current in some localities. It rarely happens that such plants have an unlimited supply of cold water for condensing purposes, and their ability to generate power at any reasonable cost is limited by the amount of steam that can be condensed with the available water. In either case, unless the power demand is low it is desirable to get the maximum practicable amount of power out of every pound of steam before it is condensed, either in manufacturing equipment or in condensers.

The necessity for this maximum of power extraction is, in most industries, increasing year by year. The installation of labor-saving machinery usually means the substitution of electrical or mechanical power for hand labor, and improvements in this direction are usually accompanied by an increase in power demand. On the other hand, improvements in manufacturing equipment are tending to reduce the consumption of steam per unit of production. As a result, many plants that have been able to generate all of their own power at very low cost, using the exhaust from prime movers in

[1] Power Engineer, The Solvay Process Co. Mem. A.S.M.E.

Contributed by the Power Division and presented at the Annual Meeting, New York, November 30 to December 4, 1925, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Abridged. All papers are subject to revision.

process, are finding that their power demand exceeds the condensing capacity of their steam-using equipment. Others are content to use obsolete and wasteful equipment because, if improvements were made, they would have an excess of exhaust steam from prime movers.

The economic considerations in applying high steam pressures to the industrial plant are fundamentally different from those of the central station, and the problem must be attacked in a different manner. Here we are not concerned with cycle efficiencies. Provided that the heat in the exhaust is fully utilized, the efficiency of the cycle is always 100 per cent. The actual efficiency is as close to 100 per cent as mechanical, electrical, and radiation losses will permit. This is true for any initial or final pressure and temperature. The water rate of the prime mover is as important in the industrial plant as in the central station, not because a low water rate saves fuel, but because it permits the generation of more power from a given quantity of steam. Mechanical, electrical, and radiation losses are relatively more important than in the central station. A radiation loss which amounts to 10 per cent of the total heat consumption in a condensing unit would amount to more than 30 per cent in a high-back-pressure machine. Certain other losses, for instance leakage past turbine blades, while objectionable because they reduce the amount of power available from the fixed quantity of steam, are less vital than in the central station, because all heat which is not converted into useful work, or lost in radiation and friction, is delivered to the process in the exhaust steam.

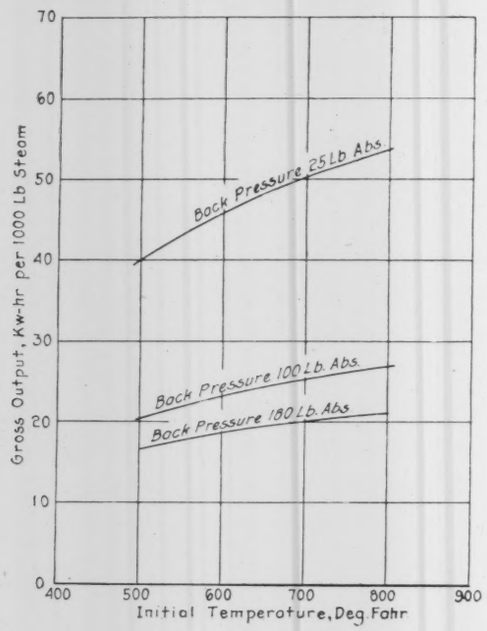


FIG. 1 EFFECT OF INITIAL TEMPERATURE ON POWER OBTAINABLE FROM STEAM AT 565 LB. PER SQ. IN. ABSOLUTE PRESSURE, FOR VARIOUS BACK PRESSURES

EFFECT OF HIGH INITIAL TEMPERATURE

High initial temperature is essential to the highest steam economy. In considering how high a pressure should be used in any particular plant, it is almost axiomatic that the temperature should be as high as the materials of construction permit. Individual designers will differ as to what the practicable temperature limit is, but the central station has demonstrated that 750 deg. fahr. is an absolutely practicable temperature and that a properly designed plant may operate with an average temperature of at least 725 deg. fahr.

Fig. 1 shows how the gross output of a non-condensing turbine, per unit weight of steam used, is increased by increasing throttle temperatures.[2] The gain is relatively less at the higher back pressures than at the lower back pressures, but is considerable under any condition.

A more important point than the increase in output per unit weight of steam is that high initial temperature produces a higher quality of exhaust steam. This makes it possible to use high initial pressures without resuperheating the steam during its expansion.

In all comparisons of pressures, a throttle temperature of 725 deg. fahr. has been assumed. It is felt that a plant can be designed for safe and dependable operation at that temperature, and the use of a materially lower temperature will not yield the best obtainable results from high pressures.

EFFECT OF INITIAL PRESSURE

Fig. 2 shows the effect on the output of increasing throttle pressures per unit weight of steam, for non-condensing turbines.[2] This is without resuperheating of the steam during its expansion, and produces exhaust steam of varying quality, depending upon the initial pressure.

It will be noted that the optimum pressure increases as the back pressure increases. With a final pressure of 25 lb. per sq. in. abso-

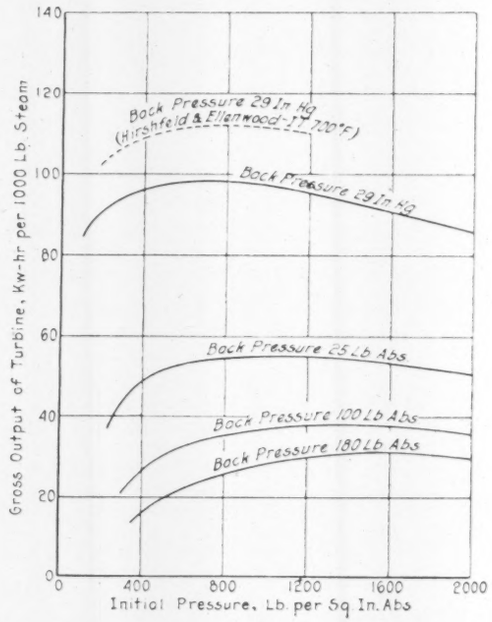


FIG. 2 EFFECT OF INITIAL PRESSURE ON POWER OBTAINABLE FROM STEAM AT 725 DEG. FAHR., FOR VARIOUS BACK PRESSURES

lute there is no gain by increasing the throttle pressure above 750 lb. At 180 lb. per sq. in. absolute back pressure, the maximum is obtained with an initial pressure of about 1550 lb. per sq. in.

For comparison with previous studies, the output per unit weight of steam for a condensing turbine has been worked out. Fig. 2 compares the result of this calculation with that of Messrs. Hirshfeld and Ellenwood.[3] The estimated output per unit weight of steam at high vacuum is considerably less than that calculated in this earlier paper. The difference is due chiefly to different assumptions in regard to turbine efficiencies. Messrs. Hirshfeld and Ellenwood based their assumption on 30,000-kw. units operating at the most economical load and under test conditions. This present paper is more concerned with units of 1500 to 5000 kw. capacity, operating under the average part-load conditions of the industrial power plant. While there is a considerable difference in numerical values, the general characteristics of the curves are the same, although the maximum output is found at a slightly lower pressure and the decrease in output with increasing pressures is more rapid at the higher pressures. For the purpose of comparing one pressure with another, the two methods of calculation are in reasonably close agreement.

No estimate has been made of the benefits derived from high pressures in the condensing industrial plant operating with poor vacuum. The gain in this case, however, is twofold, economy being improved not only by the higher initial pressure, but also by the better vacuum obtainable when condensing smaller quantities of steam.

[2] The method of estimating the power outputs shown in Figs. 1 and 2 is given in the complete paper.

[3] High Pressure, Reheating, and Regenerating for Steam Power Plants, by C. F. Hirshfeld and F. O. Ellenwood, Trans. A.S.M.E., vol. 45, p. 663.

INITIAL PRESSURE FOR SPECIFIC QUALITY OF EXHAUST STEAM

For a plant in which the quality of process steam is of no consequence, it is only necessary to know the quantity and pressure of steam required, and the amount of power to be generated. The proper initial pressure can then be determined by the method used in plotting Fig. 2.

For many plants, however, the problem is more specific. A fairly definite final superheat is required, or, in many cases, it is preferable that there should be no superheat at all in the exhaust steam, although even with saturated steam a high degree of dryness is almost always desirable.

One specific case is the selection of the proper boiler pressure for a plant in which several hundred thousand dollars worth of pumps, compressors, turbo-generators, etc. have been installed, all designed to operate with a throttle pressure of 150 lb. per sq. in. gage, and with an initial superheat of 135 deg. fahr. To maintain this pressure and superheat throughout the works it is necessary to carry a steam pressure of 165 lb. per sq. in. gage and a steam temperature of 535 deg. fahr. at the boiler plant, which latter is located

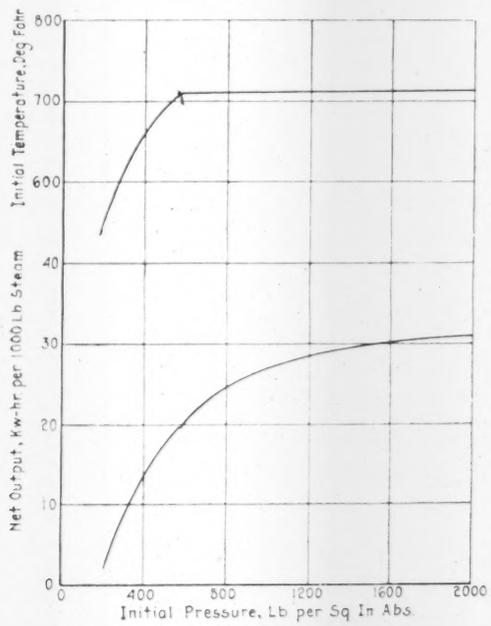


FIG. 3 INITIAL TEMPERATURE REQUIRED TO OBTAIN EXHAUST STEAM AT 180 LB. PER SQ. IN. ABS. AND 535 DEG. FAHR., WITH POWER DEVELOPED PER 1000 LB. OF STEAM. RESUPERHEATING USED AT PRESSURES ABOVE 565 LB. PER SQ. IN. ABS.; REHEAT PRESSURE, 400 LB. PER SQ. IN. ABS.

at some distance from many of the larger prime movers. The stated superheat is essential to the most efficient operation of prime movers throughout the works. It is of doubtful value in many processes, but no positive detriment from this relatively mild superheat has been encountered.

To obtain more power per unit of steam generated, the simplest procedure is to install higher-pressure boilers in the present boiler house, piped directly to high-pressure prime movers which exhaust into the existing live-steam mains. This makes a very simple installation. The only extra-high-pressure piping in the works is that from the boilers to the turbines and the feedwater piping to the new boilers. The exhaust is delivered at the most logical point for distribution to the process, and no existing equipment need be disturbed. It is necessary, in this case, to choose an initial pressure and temperature which will give not only the desired amount of power, but also a temperature of 535 deg. fahr. at the exhaust pressure.

Fig. 3 shows the quantity of power that can be generated per thousand pounds of steam used with an initial temperature of 725 deg. fahr., a final pressure of 180 lb. per sq. in. absolute, and a final temperature of 535 deg. fahr. The net power output is plotted as a function of the initial pressure.

For initial pressures up to 565 lb. per sq. in. absolute, the desired final conditions can be obtained without reheating. Above that pressure a resuperheater must be employed. In calculating the power output with reheating, a pressure drop of 5 lb. per sq. in. through the resuperheater has been assumed. This is the actual pressure drop obtained in one central station using the reheating cycle. With higher turbine efficiencies than those assumed in this paper, the maximum initial pressure, without reheating, would be correspondingly lower.

For pressures requiring resuperheat, the reheat pressure is taken at 400 lb. per sq. in. Higher outputs would be obtained by using higher reheat pressures, as shown in Fig. 4, especially at the highest initial pressures.

For pressures up to 900 or 1000 lb. per sq. in. absolute, the loss resulting from reheating the steam after it leaves the turbine, rather

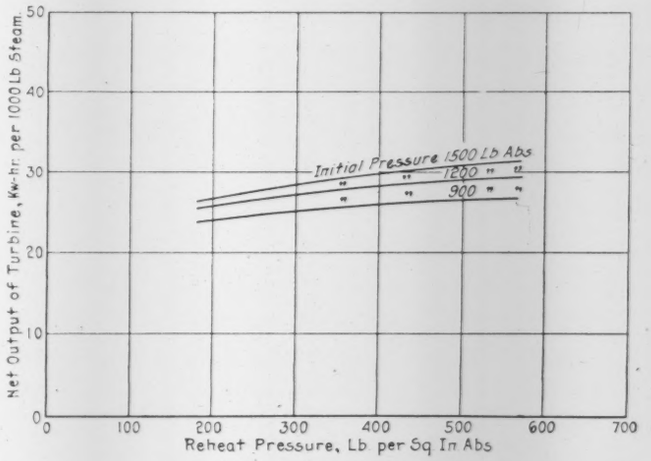


FIG. 4 EFFECT OF REHEAT PRESSURE ON OUTPUT. INITIAL TEMPERATURE, 725 DEG. FAHR.; FINAL PRESSURE, 180 LB. PER SQ. IN. ABS.; FINAL TEMPERATURE, 535 DEG. FAHR.

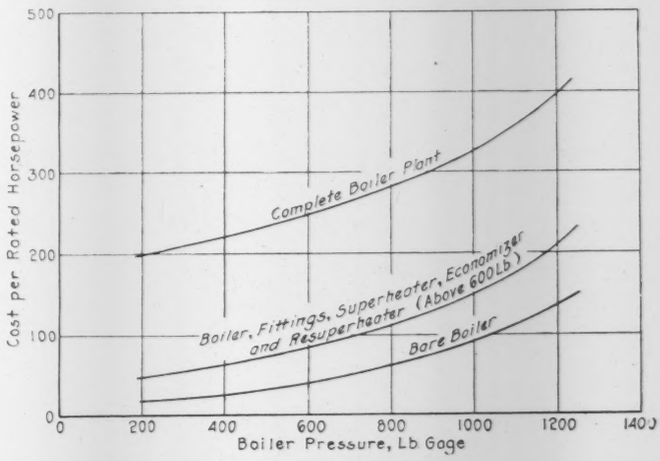


FIG. 5 INCREASE IN BOILER-PLANT COSTS WITH INCREASE OF PRESSURE

than during the course of its expansion, is small. The greater simplicity of this design, which eliminates two steam connections to the turbine and an emergency stop valve, would probably outweigh the small loss of power. This arrangement would have the added advantage that steam could be piped without reheating to those processes in which superheat is of no value, if an arrangement could be made which would insure a regular supply of steam to the reheater.

COST OF PLANT AND EQUIPMENT

Fig. 5 is an attempt to show the relative estimated costs of a plant, for one particular set of conditions, for various pressures. The plant is designed to include sufficient economizer and air-preheating surface to give the same final flue-gas temperature (300 deg. fahr.) and as nearly as possible the same operating efficiency at all pressures. No charge is included for real estate. The cost of building is about 30 cents per cubic foot. Stoker firing is assumed and stokers and

auxiliaries are designed for a maximum output of 350 per cent of boiler rating.

It will be noted that while the cost of a 1200 lb. per sq. in. boiler is about four times that of a 400-lb. unit, the cost of the complete plant at the higher pressure is less than twice as great.

The cost of a turbo-generator increases relatively less with increased pressure. While the prices vary widely with different designs, a machine for 1200 lb. per sq. in. initial pressure and 180 lb. per sq. in. back pressure will not cost more than 50 per cent more, installed, than a machine of the same size and back pressure for 400 lb. per sq. in. initial pressure.

COST OF POWER

Cost of power has been estimated as follows: To the cost of boiler plant as estimated in Fig. 5 has been added the cost of turbo-generators of sufficient capacity to use the steam generated by the boilers when operating at 200 per cent of rating. The average boiler output is assumed to be 160 per cent, but higher ratings are necessary when one or more boilers are out for inspection or repairs. From this total cost has been subtracted the cost of a 200-lb. per sq. in. boiler plant designed to produce the same quantity of steam at the same pressure and superheat as that exhausted by the turbines. This difference is taken as the cost of the power-producing equipment.

Straight-line depreciation in fifteen years, taxes and insurance at 3 per cent, and the excess cost of maintenance, labor, and supplies over that required in a 200-lb. per sq. in. boiler plant without generating equipment are added to the cost of fuel required to supply the heat consumed in the turbines. For estimating fuel costs, a boiler-plant efficiency of 85 per cent is assumed at 100 per cent load factor, 80 per cent at 50 per cent load factor, and 72 per cent at 25 per cent load factor. Cost of coal is taken at $5 per net ton, delivered at the stokers.

The resulting costs per unit of output are shown in Fig. 6. This figure is only a graphic representation of the estimated costs of power and does not indicate the best steam pressure to be used. If a similar chart were prepared for a central station, the costs should include return on invested capital, and the optimum pressure would be that at which cost is a minimum. As previously stated, the problem in the industrial plant is to get the required power from the available steam. A chart like Fig. 6 will show how much of it may be obtained more cheaply from high-pressure turbines than from other available sources.

At one plant where a high-pressure installation is being contemplated, power cannot be generated condensing for less than one cent per kilowatt-hour, and power, dependable or otherwise, cannot be purchased for less than 0.75 cent per kilowatt-hour. The load factor is exceptionally high, averaging over 80 per cent for the year, and over 90 per cent for any month. If dependable equipment could be obtained, it would pay in this case to use pressures up to 1200 lb. per sq. in., if that were necessary, to generate the required amount of power. The return on the difference in invested capital for a 1200-lb. per sq. in. non-condensing plant over a 200-lb. condensing plant would be at least 50 per cent.

The average steam demand at 165 lb. per sq. in. gage pressure and 355 deg. fahr. total temperature is over 750,000 lb. per hr. It would be possible in this plant to generate 15,000 kw. continuously at 565 lb. per sq. in. initial pressure or 20,000 kw. at 1000 lb. per sq. in. initial pressure, in turbines exhausting steam at the pressure and superheat now furnished by the boilers. With higher turbine efficiencies than those assumed in this paper, the outputs would be correspondingly higher.

THE RECIPROCATING PRIME MOVER

For the central station with peak loads of 30,000 to 700,000 kw., the only practicable prime mover in the present state of the art is the turbine. For the industrial plant with its relatively low power demand the reciprocating engine must be considered, at least in part of the field now under consideration. The mention of an engine-generator has a reactionary sound, but when its steam economy in the range of pressures under consideration is compared with that of the high-back-pressure turbine, the claims of this type of prime mover cannot be altogether ignored. With a back pressure of 180 lb. per sq. in. absolute, as much power can be generated by 1000 lb. of steam in an engine-generator operating with an initial pressure of 400 lb. per sq. in. absolute and an initial temperature of 650 deg. fahr. as can be generated in a turbine operating at 500 lb. per sq. in. absolute and 725 deg. fahr. The superheat in the exhaust is of course less, and if the same final conditions are to be obtained, the exhaust must be resuperheated.

The radiation losses in the engine are much greater than in the turbine, and consequently the net heat consumption per unit of output is greater. The overall thermal efficiency of the engine generator is relatively low, especially at light loads. For other types of prime movers, such as pumps and compressors, the overall efficiency of engine drive may be superior to that of the turbine, due to the higher efficiency of the driven apparatus.

The cost of an engine-generator to operate between 400 and 180 lb. per sq. in. absolute is about 30 per cent higher than for a turbo-generator of the same capacity operating under the same conditions. On account of its greater weight and larger space requirements, the total installation cost would be twice as much for the engine as for

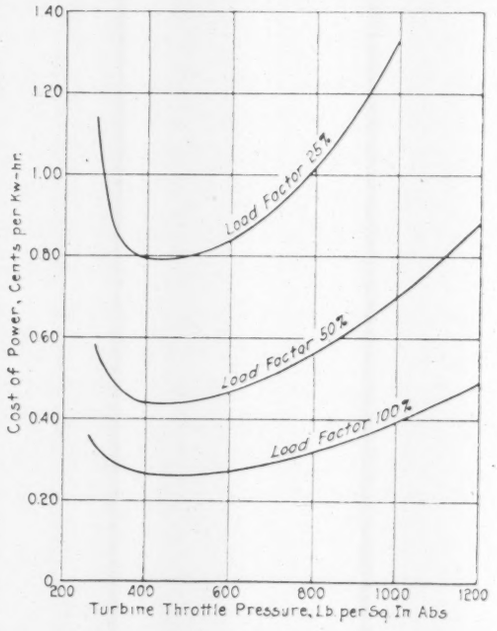


FIG. 6 EFFECT OF INITIAL PRESSURE ON COST OF POWER. THROTTLE STEAM TEMPERATURE, 725 DEG. FAHR.; EXHAUST STEAM PRESSURE, 180 LB. PER SQ. IN. ABS.; EXHAUST STEAM TEMPERATURE, 535 DEG. FAHR.

the turbine. For equal power developed from a given amount of steam, the cost of the engine installation would be somewhat less than that of a turbine due to the fact that a lower pressure could be used. Which type of prime mover will furnish the cheaper power is largely a function of load factor, the higher first cost of the turbine plant being the more important factor at low load factor, and the higher heat consumption of the engine being the more important factor at high load factor.

No brief is held for the reciprocating engine for the generation of power. The greater space occupied, the very much greater weight, the contamination of the exhaust with lubricating oil, and problems presented by stuffing boxes at very high pressures, all go far to counterbalance the better steam economy. While a greater amount of power can be generated in the engine from a given quantity of steam, the net effect at the coal pile is the same as if part of the power were generated in high-back-pressure turbines, and the remainder in condensing units. A solution most to be desired is that the turbine designers may produce small-sized high-pressure machines which approximate the steam economy of the reciprocating engine without greatly increasing the selling price. Considerable progress has been made in this direction lately on small condensing units, similar development has been made in the high-pressure non-condensing field abroad, and equal progress may be expected soon in this country.

THE VALUE OF HIGHER BACK PRESSURES

In plants where the power load is low in proportion to the exhaust-

steam demand, higher initial pressures may be desirable in order to permit the use of higher back pressures.

The capacity of many kinds of steam-heating equipment is increased with increased pressure, or conversely, the size and cost of equipment for a given output is decreased with increased steam pressure. Higher pressures in evaporating processes usually increase the capacity, the heat economy, or both.

A typical case is that of a plant using multiple-effect evaporators for the concentration of a liquor. Steam at 150 lb. per sq. in. and 135 deg. fahr. superheat is used in prime movers, exhausting at 10 lb. per sq. in. gage. The exhaust steam, which is approximately 94 per cent dry, is used as a heating medium in triple-effect evaporators. By increasing the back pressure to 25 lb. per sq. in. a fourth effect could be used, reducing the steam consumption approximately 25 per cent. By increasing the initial pressure to 375 lb. per sq. in. and the initial temperature to 625 deg. fahr., the same quantity of power could be generated on this reduced quantity of steam. That is, the total power and heating demand could be taken care of with 25 per cent less steam. The total heat of steam as supplied to the prime mover would be greater, but the heat returned to the boilers in the drip from the first-effect evaporator would also be higher; the actual heat consumed per pound of steam would be slightly less. There should be a net fuel saving in the complete operation of at least 25 per cent.

Many plants are using live steam in process work at 40 to 100 lb. per sq. in. pressure. Reducing the pressure from that supplied at the boilers often results in a troublesome degree of superheat, as well as in a waste of available energy. High-back-pressure prime movers remedy this situation.

More advance has been made by industrial plants in the field of high back pressure than in the field of high initial pressure. The latter is a most logical development from the former.

Higher Pressures for Heating Equipment

Manufacturers of heating equipment such as evaporators have made little change in limiting pressures in the last twenty years. Pressures up to 100 lb. per sq. in. were used on large evaporators at least twenty years ago, and very few, if any, large evaporators have been built for higher pressures.

While temperature increases rather slowly with increased pressure, it is usually possible to increase the efficiency of an evaporating process by increasing the steam pressure. With a highly concentrated liquor which has such a high boiling temperature that only single-effect evaporation can be used with steam at 100 lb. per sq. in. pressure, two effects could be used with a pressure of 250 lb. per sq. in. without reducing the mean temperature difference between the steam and the liquor.

The design of an evaporator with a shell 16 or 20 ft. in diameter for very high pressures presents some problems, but few which have not been solved in the Scotch marine boiler. The advantages of higher pressure for process, particularly in plants with a low power demand, are so great that considerable development in this direction may be expected in the near future.

Feedwater for High-Pressure Boilers

Obtaining suitable feedwater is one of the more serious problems which will confront the majority of industrial plants contemplating the use of high-pressure boilers.

The decreasing solubility of calcium sulphate with increasing temperature makes many treated waters which are fairly satisfactory at 200 lb. per sq. in. pressure almost unfit for use at 600 lb. per sq. in. Dilution by blowdown is more costly at high pressures. The consequences of a rupture, resulting from scale formations, are more to be feared at the higher pressures. If possible, only distilled water should be fed to high-pressure boilers.

The condensing plant, provided the condensers are tight, returns 90 per cent or more of the total feed to the boilers as practically pure distilled water. The quantity of make-up is so small that the raw water can be evaporated without much expense and it is possible to feed boilers with water almost free from solids.

In the industrial plant, condensate may be returned from some apparatus, but with direct contact heaters, such as distillers, vulcanizers, and digesters, no condensate can be recovered.

In such cases a pure-water supply could be obtained by condensing the exhaust in single-effect evaporators. These evaporators, fed with raw water, supply vapor to the process, and the condensed exhaust steam is returned to the boilers. No heat loss, other than radiation, is involved, and there is a material advantage in the fact that leakage is necessarily outward, and if the evaporators are properly operated, there is no possibility of contaminating the condensate with raw water. There is, of course, a loss of energy involved because the prime movers must exhaust at a higher pressure than that required in the process; otherwise there would be no temperature head available for the evaporation of raw water. If a high temperature difference is maintained in order to keep down the cost of the evaporating equipment, this loss of energy may be considerable.

Some distilled feedwater may be obtained from most direct-contact heaters without loss of energy by flashing the hot discharge liquor and using the vapor for multiple-effect evaporation of raw water. The amount of water that can be recovered in this way is small. Vulcanizer drip at 320 deg. fahr., flashed in four stages and used in quadruple-effect evaporators would not yield more that 25 per cent of its own weight in distillate.

The cheapest method of obtaining pure feed may be, in the majority of cases, to evaporate the total-make-up, multiple-effect, with steam at fairly high pressure.

Commercial Limitations

The limiting pressure for present-day plant design is set, not by the calculated minimum cost, but by the ability of manufacturers to supply the required equipment.

At this writing the boiler and valve manufacturers are the only ones who appear entirely willing to supply equipment for pressures much above 600 lb. per sq. in. gage.

Boilers of practically any capacity may be obtained for pressures up to 1200 lb. per sq. in. Valves at least as large as six-inch are obtainable for the same pressure.

At least one turbine manufacturer is willing to quote on small high-back-pressure turbines for initial pressures of 1000 to 1200 lb. per sq. in., but this company prefers to build its first machine of this kind in a larger size than could be used by the majority of industrial plants. Other turbine manufacturers are reluctant, for the present at least, to quote on any turbines for pressures higher than 600 lb. per sq. in. This is undoubtedly a temporary condition and one which will be changed as soon as the operating data on the one higher pressure unit so far built are available.

Engines are in use operating at 400 lb. per sq. in. gage, and at least one engine builder is willing to supply reciprocating equipment for pressures up to 600 lb. per sq. in. gage.

Boiler, turbine, and valve manufacturers accept temperatures up to 750 deg. fahr., but the engine builders set a limit 100 deg. fahr. lower. While the lubrication problem at high temperatures is a formidable one, the difficulties confronting the engine designer would appear to be less, on the whole, than those which have been overcome by the turbine designer. If a field is created for the high-pressure steam engine, there is little doubt that it will be soon adapted to operate with higher temperatures as well as higher pressures.

Central stations have demonstrated the practicability of 600 lb. sq. in. as a working pressure, and of 750 deg. fahr. as a working temperature. They will soon demonstrate whether or not 1200 lb. per sq. in. is equally practicable. This leaves very little development or experiment necessary for the industrial plant. Boilers, boiler auxiliaries, and valves would be the same in the industrial plant as in the central station. Turbine design should be simpler on account of the much lower range of temperatures in the high-back-pressure machine than in the condensing unit. Leakage and other handicaps to the smaller-sized unit are not so serious in this type of machine, where all of the heat not used in actual work or lost in radiation is available for use in process.

When both the plant designer and the equipment manufacturer are thoroughly awake to the possibilities of higher steam pressures in the industries, commercial development in this field should be even more rapid than it has been in the central station. Because the gains are greater there, and the problems less difficult, it is probable that the eventual field for the highest steam pressures is in the industrial plant.

Production Control in the Newsprint Industry

An Outline of the Manufacturing Processes and Production Methods of a Majority of the Mills in North America Making "Standard" Newsprint Paper

By GEORGE D. BEARCE,[1] NEW YORK, N. Y.

IT HAS often been stated that the consumption of paper is the measure of a nation's civilization, and if the increased use of newsprint paper on the North American continent is any criterion, it would indicate that our enlightenment has made rapid strides during the past fifteen years. The consumption in the United States was 25 lb. per capita in 1910 and 50 lb. in 1924, and increase of 100 per cent.

The cost of buildings, equipment, and working capital for a balanced mill that will produce 200 tons of newsprint paper per day is approximately $10,000,000, or about $50,000 per ton of product. This figure would include the subsidiary pulp-making units, such as the groundwood and sulphite mills and the steam plant, but not outside hydroelectric development nor timber lands, which might increase the capital outlay 50 to 100 per cent, depending upon conditions.

Pulp- and Paper-Manufacturing Processes

All pulp used in the manufacture of newsprint paper is made from wood, and the principal varieties used are spruce, balsam, and hemlock. There are two methods of reducing wood to pulp, namely, (1) mechanical and (2) chemical.

The sulphite chemical process is used in the newsprint industry, and this reduction of wood to pulp consists in cutting the wood blocks into small chips and cooking them in a large steel, brick-lined "digester" under steam pressure, together with the necessary cooking liquor or bisulphite acid made from pure sulphur and lime rock. The resultant pulp is a long-fibered cellulose stock, which after being properly washed and screened is ready for use in the paper mill.

The mechanical or groundwood pulp process consists of forcing, by hydraulic pressure or other means, the wood sticks against a rapidly revolving "grinderstone" similar to the old-fashioned grindstone. The surface of the grinderstone is prepared in a special manner and the fibers are torn from the wood block, resulting in a shorter-fibered pulp than is made by the sulphite process. Groundwood pulp includes both lignin and cellulose, consequently its physical and chemical characteristics are different from those of sulphite pulp.

The production of newsprint paper consists of combining the groundwood and sulphite pulps in their proper proportions, together with any necessary fillers or colors. This mixture properly prepared and controlled as to density comes on to the paper-machine wire about 99½ per cent water. There are four major steps in making a continuous sheet of paper: 1, Forming a uniform sheet or web of paper on the wire and removing a large amount of water by gravity and suction; 2, pressing the formed sheet between heavy rollers to compress it and remove more moisture; 3, drying the sheet, which enters the drier section at about 70 per cent moisture, by means of large revolving steam-heated cylinders; and 4, finishing the paper by passing it through a series of heavy steel calender rolls that further compress the sheet and smooth its surface.

Newsprint paper as a product is fairly well standardized as to weight, quality, color, strength, etc., because most of it is used by the large newspaper-publishing organizations and the requirements of modern newspaper presses are similar. Newsprint paper is approximately 75 per cent groundwood and 25 per cent sulphite pulp, together with any other necessary materials such as alum, color, and filler. The operation is further standardized because the paper is made in a continuous sheet over machines operating 24 hours a day and for six days a week. Production control and standardized methods of developing reports are consequently greatly simplified.

[1] Engineer, News Print Service Bureau. Mem. A.S.M.E.

Contributed by the Management Division and presented at the Annual Meeting, New York, November 30 to December 4, 1925, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Slightly abridged.

Control methods are essential because of the varied processes and the large machines required in operation, although the man-power per ton of product is relatively small as compared with other industries or with mills which make the finer grades of paper.

Various systems of production control both for quantity and quality have been developed for the several major operating departments. The quality of both the groundwood and sulphite pulps has a marked effect upon the operating efficiency of the paper machines and consequently its control in the pulp-producing departments is especially important.

Sulphite Mill

The type of report generally used to record the manufacture or cooking of sulphite is illustrated by Fig. 1. The essential features

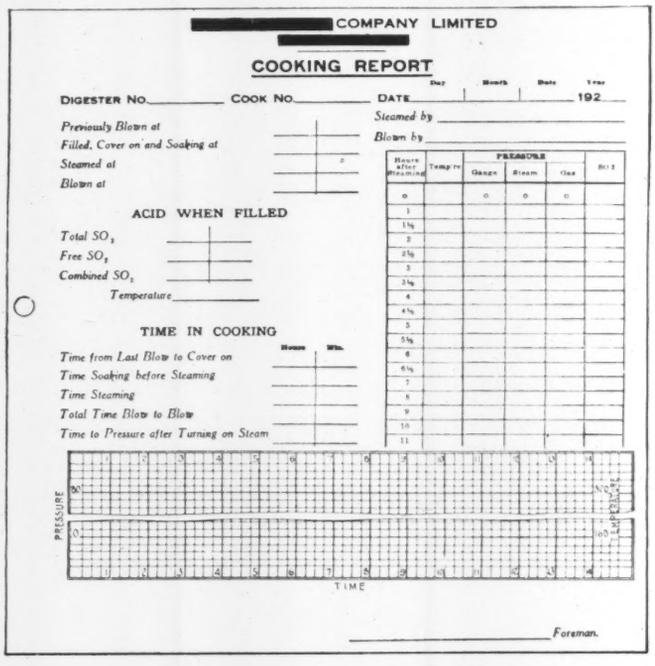


FIG. 1 SULPHITE COOKING REPORT

included in this report are used by practically all modern mills, although they are varied to suit the individual operating conditions. The test of the acid used and the pressures of both steam and gas during the cooking process are carefully watched because they are guides to operation and have a very important effect on the quality of the pulp. Many mills plot predetermined pressure and temperature curves on the cross-section part of the report, and the "cook" in charge of operation is expected to follow these standard cooking conditions as closely as possible. The results of each "digester cook" or "blow" are recorded on this type of report, thus providing data that can be used to make an analysis at any time and assist in standardizing the quality of the product that is used in subsequent operations.

Groundwood Mill

The control of both the quantity and quality of mechanical pulp is more important than that of sulphite pulp because the finished paper consists of approximately 75 per cent of groundwood. The majority of mills have established some method of periodically testing the pulp, and Fig. 2 illustrates the major data that are recorded for control purposes. The "freeness" test is commonly used to indicate the quality of the pulp and indicates to a large degree its action on the paper machines.

Although the character of the pulp is altered by changes in pressures, speed, and temperatures, the most important feature is the condition of the face of the "stone" which is constantly changing in the process of defibering the wood blocks. The freeness test indicates the condition of the stone and whether it should be reconditioned, i.e., sharpened or dulled. A number of mills test the groundwood pulp made by each grinder every one to two hours, while others obtain similar information from a group of grinders. Some mills keep the information as a record of results, but others post the information before the operating crews at stated intervals,

[redacted] PULP AND PAPER CORPORATION

GROUND WOOD MILL DAILY REPORT

[redacted]

DATE ENDING 8 A. M. _____ 192

SHIFT	GRINDER 1		GRINDER 2		GRINDER 3		GRINDER 4		GRINDER 5		GRINDER 6		GRINDER 7		GRINDER 8		GRINDER 9		TOTAL	
	HRS	CDS	HRS	CDS	HRS	CDS	HRS	CDS	HRS	CDS	HRS	CDS	HRS	CDS	HRS	CDS	HRS	CDS	HRS	CDS
No. 1																				
No. 2																				
No. 3																				

TOTAL DAYS RUN

TIME LOST, HOURS

SHIFT	POWER	REPAIRS	OTHER REASONS:	SPEED	PRESSURE	TEMP.
No. 1						
No. 2						
No. 3						

FREENESS

Time	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	Decker	Strength	Jingo

Remarks:

FIG. 2 GROUNDWOOD MILL REPORT

thus keeping those responsible for operation continually informed in regard to the quality of product.

PAPER MILL

The paper mill is the major operating department. The mixed and properly proportioned pulps go on to the paper machine in the form of a milky liquid which is 99½ per cent water, and leave the machine as a continuous web of paper which is of uniform thickness and strength, and has a moisture content of about 8 per cent. This continuous and complicated process, through the several sections of the paper machine that dewater and dry the paper, requires close control of operation to obtain a product that will come up to the quality requirements and at the same time maintain the volume of production that is necessary for the successful operation of any paper machine. Figs. 3 and 4 illustrate the general information obtained by many mills, although each plant has developed reports to suit its conditions. The use of these data, whether posted for the information of the machine crew or kept as a record, is dependent upon the policy of the management.

From a management standpoint the time lost in the operation of a paper machine is one of the most important factors in production, because it costs $50 to $60 per hour to run a large modern machine making 3 or 4 tons of paper hourly. The causes for any lost time are therefore carefully recorded, together with the speed, tonnage, and other production factors.

Although quality is not considered as important in newsprint as in finer grades, it is nevertheless taken into consideration, and

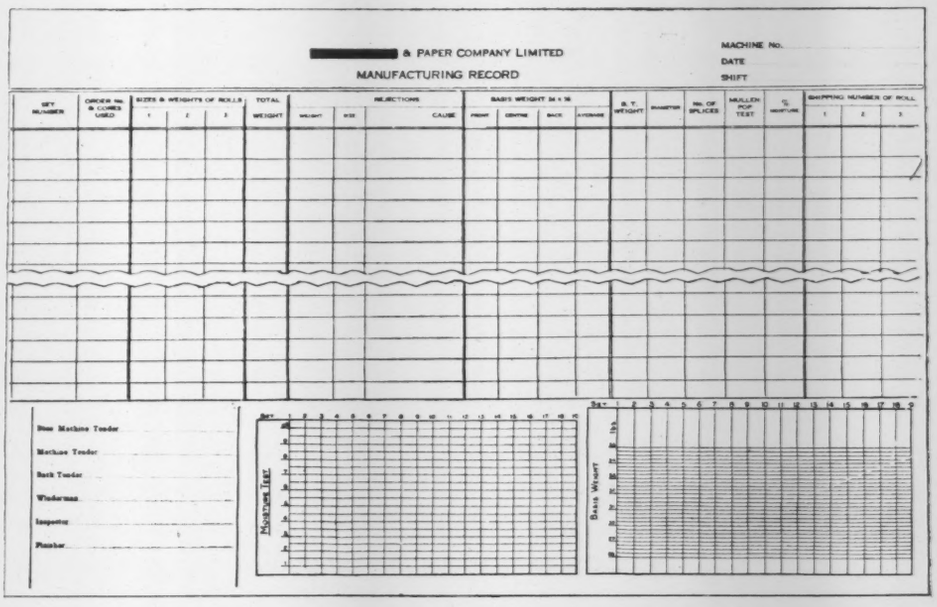


FIG. 3 PAPER-MILL REPORT

(The major information required to record the production of each machine is indicated on this form. The speed and trim of the machine, the basis weight, time losses, etc. are all important data which are used in subsequent reports to analyze the efficiency of operation.)

Fig. 4 illustrates a very satisfactory method of control used by several mills. The basis weight, "pop test," moisture, and finish are all of major importance in obtaining the quality paper that meets the requirements of the consumer. These factors together with the others shown on the quality report are all considered in the analysis of the final product. When they are weighed with the machine-crew efficiency an adequate yardstick is established that will measure the operating results of each machine crew from a standpoint of *quality* and *quantity*.

STANDARD OPERATING REPORTS

About five years ago a committee was formed composed of representatives of manufacturers associated with the News Print Service Bureau, and the three following major reports were selected and standardized in detail, because they present operating information that has a very direct effect upon the final cost of the product. These reports are:

1 Paper-mill operating
2 Machine clothing and wires
3 Steam-plant efficiency.

A manual of instructions was adopted covering the detailed methods to be followed in compiling these reports, and all of the items that enter into the calculation of the figures were concisely defined.

These reports provide a basis which can be used by both the management and operating departments to localize the responsibility for operating results, and serve as both a control medium on current operations and a permanent record for comparative purposes within the plant. The secondary reason for establishing the standard method was to enable the companies which manufacture the same grade of product to compare results of operation between mills and by machines.

Paper-Mill Operating Report. The paper-mill report shows the vital information in regard to paper-machine operation. Paper is made in a continuous sheet and therefore it is possible to determine the capacity production of any paper machine by using the recognized theoretical formula involving the speed of the paper travel in feet per minute, the width of the sheet across the machine, and the weight of the paper made. This production report, Fig. 5, divides the various time and production losses into two groups. The first is called "mill losses" and consists of any lost time that is caused by general plant conditions chargeable to management rather than to any specific department or crew. Such items as lack of power, lack of orders, and major breakdowns are in this group. The second group is termed "machine production losses" and includes those factors that are within the direct control of the

[redacted] & PAPER COMPANY, LIMITED

QUALITY OF NEWSPRINT

Machine No. _____ Date _____

Actual Values

Ideal Roll's	Lbs. Basis Wt.	Lbs. Tap Test	% Moisture	100 Cleanliness	100 Formation	0020 In. Thickness	100 Finish	Colour	100 Total Weight Value	Breaks	Time Down	Production
8-4												
4-12												
12-8												
Average												
Average for last week										TOTAL PRODUCTION		

Shift	Machine Tender	Back Tender	Back Pressure	Speed	
8-4					
4-12					
12-8					

FIG. 4 QUALITY RECORD, PAPER MILL

(Various tests of quality are made by standard testing equipment and recorded. Each factor is allotted a value according to its importance and an overall figure is obtained that indicates the quality of paper.)

Sample Report

Mill Blank Paper Co. PAPER MILL OPERATING REPORT Month February 1925

	MACHINES No. 1	No. 2	No.	No.	No.	No.	No.	No.	Month	Cumulative
1. Scheduled Operating Hrs.	600	600							1200	2400
2. Actual Operating Hrs.	590	580							1170	2310
3. Operating Hrs. %	98.35	96.70							97.52	96.27
4. Mill Loss — Breakdowns %	1.65	1.20							1.43	3.20
5. Power %		2.10							1.05	.53
6. Lack of Orders %										
7. *Miscellaneous %										
8. Total %	1.65	3.30							2.48	3.73
9. Actual Average Speed (Ft.)	620	700							x x x	x x x
10. Operating Capacity Trim (Inches)	146.1	146.8							292.9	291.4
11. Actual Average Trim (Inches)	140.5	143.6							284.1	282.8
12. Loss in Trim %	3.83	2.18							3.00	2.95
13. Capacity Production (Tons per Day)	58.15	66.30							124.45	122.4
14. Actual Production (Tons per Day)	52.37	58.32							110.69	107.1
15. MACH. CREW EFFICIENCY %	93.08	90.14							91.94	90.45
16. Mach. Prod. Loss—Felts, Wires %	1.04	1.48							1.26	2.06
17. Wash-ups %	1.19	1.24							1.17	1.14
18. Broke and Culls %	3.95	7.14							5.63	6.35
19. Total %	6.12	9.86							8.06	9.55
20. PLANT EFFICIENCY %									86.73	84.24
21. Actual Basis Weight (Lbs.)	32.12	32.24							32.18	31.95
22. Actual Lbs. per Inch Trim	745	812							779	758
23. Lbs. per Inch Trim (32 lb. Basis)	742	806							775	759
24. Trim Speed Production Factor	119.5	115.1							117.3	115.5
25. Materials—Sulphite %									28.1	28.6
26. Groundwood %									77.3	77.4
27. Other Fibres %									1.1	0.5
28. Fillers %									0.6	.8
29. Total %									107.1	107.3
30. Moisture in Paper %									9.46	9.21
31. Dry Fibre in Sheet to Dryers %									32.1	31.2
32. Lbs. Steam per Ton of Paper									8467	9110

Special Note* _____ Reported by _____

FIG. 5 STANDARD PAPER-MILL OPERATING REPORT

Mill _____ REPORT OF MACHINE CLOTHING AND WIRES Month _____ 192

		MACHINE No.	No.	No.	No.	No.	No.	No.	No.	TOTAL	AVERAGE
WIRES	Number of Wires for Period										
	Total Sq. Ft. of Wires for Period										
	Tons Paper per Unit (Sq. Ft.)										
	Cumulative No. Wires to date										
	Cum. Sq. Ft. of Wires to date										
	Cum. Tons Paper per Unit (Sq. Ft.)										
JACKETS	Number of Jackets for Period										
	Total Lbs. of Jacket for Period										
	Tons Paper per Unit (Lb.)										
	Cumulative No. Jackets to date										
	Cum. Lbs. of Jackets to date										
	Cum. Tons Paper per Unit (Lb.)										
1ST FELTS	Number of 1st Felts for Period										
	Total Lbs. of 1st Felts for Period										
	Tons Paper per Unit (Lb.)										
	Cumulative No. 1st Felts to date										
	Cum. Lbs. 1st Felts to date										
	Cum. Tons Paper per Unit (Lb.)										
2ND FELTS	Number of 2nd Felts for Period										
	Total Lbs. of 2nd Felts for Period										
	Tons Paper per Unit (Lb.)										
	Cumulative No. 2nd Felts to date										
	Cum. Lbs. of 2nd Felts to date										
	Cum. Tons Paper per Unit (Lb.)										
3RD FELTS	Number of 3rd Felts for Period										
	Total Lbs. of 3rd Felts for Period										
	Tons Paper per Unit (Lb.)										
	Cumulative No. 3rd Felts to date										
	Cum. Lbs. of 3rd Felts to date										
	Cum. Tons Paper per Unit (Lb.)										
TOP DRYERS	Number of Top Dryers for Period										
	Total Lbs. of Top Dryers for Period										
	Tons Paper per Unit (Lb.)										
	Cumulative No. Top Dryers to date										
	Cum. Lbs. Top Dryers to date										
	Cum. Tons Paper per Unit (Lb.)										
DRYERS BOTTOM	Number of Bot. Dryers for Period										
	Total Lbs. of Bot. Dryers for Period										
	Tons Paper per Unit (Lb.)										
	Cumulative No. Bot. Dryers to date										
	Cumulative Lbs. Bot. Dryers to date										
	Cum. Tons Paper per Unit (Lb.)										

Special Note _____ Reported by _____

FIG. 6 STANDARD FORM FOR MACHINE CLOTHING AND WIRES

Sample Report

STEAM PLANT EFFICIENCY REPORT

Mill Blank Paper Co. Month February 192 5

	Period	Cumulative
1. Steam Pressure (Lbs. per Sq. In.)	147	146
2. Temperature of Steam	529	516
(a) Quality of Steam (Degrees Superheat or % Moisture)	158	151
3. Feedwater (a) Temperature Entering Boilers	250	252
(b) Temperature Entering Economizers	150	154
(c) Increased Temperature Due to Economizers	100	98
4. Flue Gas (a) Temperature Leaving Boilers	560	554
(b) Temperature Leaving Economizers	400	396
(c) Decrease of Temperature due to Economizers	160	158
5. Fuel Used, (as fired) (a) Coal	14,696,700	29,482,000
(b) Wood (Actual Lb.) Equiv. Coal Basis		
(c) Fuel Oil (Actual Lb.) Equiv. Coal Basis		
6. Equivalent Dry Fuel Used (Total)	14,679,439	28,159,880
7. Total Weight of Water Fed to Boilers (Feedwater Meter)	122,544,000	284,651,000
8. Total Weight of Steam Generated (Flow Meters)	117,965,000	238,144,000
9. Factor of Evaporation for Water Entering Economizers	1.109	1.191
10. Total Equivalent Evaporation from and at 212°	141,440,000	271,996,000
11. Equivalent Evaporation from and at 212° per Lb. Equivalent Dry Fuel Used	10.07	9.67
12. Equivalent Evaporation from and at 212° per 10,000 B. t. u.	7.56	7.25
13. Per cent Rating Developed	138	145
14. EFFICIENCY OF BOILER, FURNACE AND GRATE	67.7	67.1
15. EFFICIENCY OF PLANT WITH ECONOMIZERS	73.2	70.3
16. Final Coal Analysis:		
(a) Moisture (As fired)	4.25	4.58
(b) Volatile Matter (Dry)	30.90	32.10
(c) Fixed Carbon (Dry)	57.20	54.80
(d) Ash (Dry)	11.90	13.10
B. t. u. per Lb. (Dry)	13,290	13,340
17. Combustible in Ash %	25.18	26.85

REMARKS

All Temperatures in degrees Fahrenheit. All Weights in Pounds.
All Pressures are Gauge Pressures. 1 Boiler H. P.—10 Sq. Ft. Heating Surface.

Reported by _____

10

FIG. 7 SAMPLE REPORT, STEAM-PLANT EFFICIENCY REPORT

NEWS PRINT SERVICE BUREAU

STEAM

COMPARATIVE STATEMENT OF CONVERSION COSTS

PER 1000 LBS. DELIVERED

		Month	Cum
1	LABOR - SUPERINTENDENTS		
2	FIREMEN		
3	GENERAL		
4	TOTAL LABOR		
5	FUEL HANDLING EXPENSE		
6	POWER - ELECTRIC		
7	LUBRICANTS		
8	SUPPLIES		
9	REPAIRS LABOR		
10	MATERIAL		
11	REPLACEMENTS - LOSSES ETC		
12	MILL CONVERSION COST (EXCLUDING OVERHEAD)		
13	DEPRECIATION		
14	TAXES		
15	INSURANCE		
16	MANUFACTURING BURDEN		
17	MISCELLANEOUS		
18	TOTAL CONVERSION COST		
19	FUEL - COAL		
20	WOOD		
21	OIL		
22	ELECTRIC STEAM		
23	TOTAL FUEL COST		
24	TOTAL COST PER 1000 LBS DELIVERED FROM AND AT 212° F		
	STEAM DISTRIBUTION		
	1000 LBS TO NEWS MILL:		
25	PROCESS		
26	HEATING AND VENTILATING		
27	MISCELLANEOUS		
28	TOTAL		
	1000 LBS TO SULPHITE MILL:		
29	PROCESS		
30	HEATING AND MISCELLANEOUS		
31	TOTAL		
32	OTHER USAGES		
33	TOTAL 1000 LBS DELIVERED FROM AND AT 212° F		
34	% BOILER HOUSE STEAM TO TOTAL DELVD.		
35	TOTAL EQUIVALENT TONS COAL CONSUMED		
36	EQUIVALENT EVAPORATION PER 10,000 B. T. U.		
37	POUNDS STEAM DELVD. PER $ CONVERSION COST		
38	" " " " " TOTAL COST.		
39	% ELECTRIC STEAM TO TOTAL DELIVERED		

FIG. 8 FORM FOR STEAM-PLANT COST REPORTS

machine crews, thus allocating the responsibility for definite production losses in paper-machine operation.

The machine-crew efficiency, calculated by using the actual and capacity production, is a measure, on a percentage basis, of the operating results attained by any particular crew or machine, while the production losses, compiled on the same basis, explain why the crew or machine did not achieve a 100 per cent production. Plant efficiency is a general overall figure that takes into consideration all losses on all machines and is the indicator that shows the general results obtained by any mill. In addition this report covers points such as moisture in paper, pounds of steam per ton of paper,

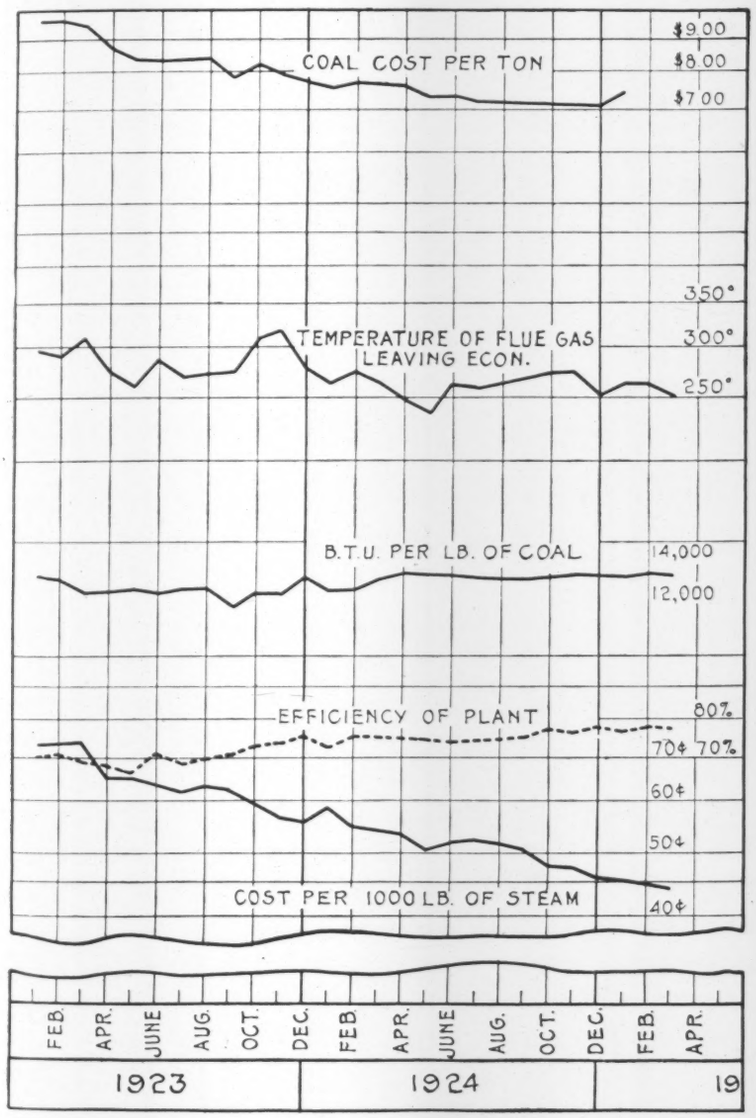


FIG. 9 STEAM-PLANT OPERATION, MILL "A"

and other information that has a direct bearing on both the efficiency and cost of paper-machine operation.

Machine Clothing and Wires Report. Machine clothing and wires are being constantly used up and worn out on the paper machine, and form an important controllable item in the final cost of product. A standard unit was developed in reporting the figures covering this type of equipment on 32-lb. newsprint, so that it is possible to compare machines of various sizes, as well as different makes of wires, felts, etc. independently of any fluctuations in the prices of wires and felts. This elimination of the price factor provides a figure that measures the combined efficiency of the equipment and its utilization. Highly satisfactory operating results from any wire or other piece of equipment may be due to

1 Design and quality of felts and wires
2 Attention given by machine crews to the installation and operation of equipment, and
3 The mechanical condition of the paper machine and its wear on the wires and machine clothing.

Although the report illustrated in Fig. 6 does not provide an analysis of different makes or designs of felts or wires, the detailed data necessary to calculate the figures show the results obtained by the use of any particular piece of equipment. The operating crews are, to some extent, held responsible for the life of felts and wires, and this report provides data that can be intelligently used in the study of such problems.

Steam-Plant Efficiency Report. Steam and power used in making newsprint paper represent approximately 40 per cent of the conversion cost. In order to obtain accurate and detailed information regarding the operation of the boiler house, the steam-plant efficiency report, Fig. 7, and the steam-plant cost reports, Fig. 8, were developed. The steam plant makes and delivers steam to the other consuming departments, and is therefore treated as a distinct unit in pulp- and paper-mill operation. The efficiency report is based on the 1923 A.S.M.E. power test code for stationary boilers, and therefore represents standard practice. It was recognized that the overall efficiency of plant and other related figures are dependent upon the accuracy of readings from the available fluid meters and other measuring devices used in the modern boiler house. However, the reports indicate that the figures are quite reliable if the metering equipment is well cared for and regularly tested.

The steam-plant cost report is closely allied to the operating report and is necessary to analyze the efficiency. It is based on the steam delivered at the boiler-house walls, and in addition to showing the itemized cost of steam per 1000 lb. of steam from and at 212 deg. fahr., it gives in detail the consumption by the several departments. These two reports are interdependent and are both essential in the analysis of steam-plant operation. The efficiency is a measure of boiler-house performance that is vital to the engineer in plant operation, and the cost is the court of last appeal that judges and interprets operating results.

MILL COMPARISONS

There are fifty-two companies associated with the News Print Service Bureau in the United States, Canada, and Newfoundland. About ten of the mills started coöperating in the exchange of figures less than five years ago, and at the present time thirty-four companies making standard newsprint, located in the United States and Canada from coast to coast and in Newfoundland, participate in this regular exchange of production-control reports. About eleven additional companies making other grades of paper have also joined in the exchange of steam and sulphite reports.

The standard production reports illustrated as well as conversion costs of newsprint rolls, groundwood, sulphite, and steam are sent to the News Print Service Bureau by the coöperating mills on the special forms provided. They are then tabulated on a special comparative statement, duplicated, and returned to the contributing mills, together with the index list giving the name and number of each company. The accountants and engineer on the staff of the Bureau visit the various coöperating mills to determine whether or not the reports are compiled on a standard basis and to make suggestions regarding them.

RESULTS OF COMPARISONS

The actual economies brought about by such a broad and effective comparison of operating results can hardly be estimated, although it is certain that every coöperating mill has been able to make definite improvements in operation that would not have been possible without the data supplied by these reports.

One of the specific cases where actual savings have been made, because of the information made available by the comparison of steam-plant costs and efficiencies, illustrates the powerful force behind this system of comparisons. A medium-sized mill had a poor record in its steam plant and in steam utilization. The movement started at the top with the president of the company, who

noticed the poor position on the comparative statement. Every one in the organization started to work on the problem, and plant design, furnace construction, boiler operation, quality of fuel, operation of stokers and boilers, as well as every other detail connected with the boiler, were carefully considered and studied. The results were highly gratifying, and with only minor inexpensive changes in equipment they made savings that well repaid all for their work and appreciably lowered their costs.

In graphic form Fig. 9 shows the progress of their steam plant in efficiency of operation and cost of steam per 1000 lb. covering the years the work was in progress. The figures were further substantiated by the actual coal consumption for two different years under similar steam demands. As the assistant manager aptly stated the case, "The increased efficiency and decreased cost may appear extraordinary, but I can show the records in the purchasing department and our coal cost is $60,000 less in 1924 than it was the previous year, and not over $20,000 of this is due to the difference in prices. Moreover, we are not through yet and better results will be obtained in the future."

The comparison of operating results between different mills which has been described is a splendid tribute to the broad and just principles of the many executives in control of the various mills in the industry. Such a comparison does not stifle the spirit of competition between companies, but rather enhances it. Moreover it does not interfere or concern in any way the policy of any particular company or companies. It does provide them with reliable data based on standard methods that form a valuable instrument in the analysis of their particular problems, and supplies both the executive and workman with incentives based on a non-remunerative appeal that stimulates the individual and collective efforts of all concerned. In effect it endeavors to point out "the one best way" to improve the efficiency of an *entire industry*, and is based on sound common sense and lawful principles.

Discussion

HAROLD ANDERSON[2] submitted a written discussion in which he stated that there was supposed to be a certain economical life of felt which should not be exceeded, as the steam consumption for drying purposes increased at too great a rate, and he wondered whether any attention was paid to this in newsprint manufacture.

The tendency nowadays was to increase the paper speed up to 1000 ft. per min. and possibly more. While this of course would increase the production of a machine of given size, it would be interesting to know whether this was an unmixed blessing. In other words, did not this higher speed result in increased breakage of the paper, particularly when an old machine was speeded up? In addition, did it not to a certain extent limit the amount of groundwood that might be used? He had heard rumors of as much as 85 per cent being used experimentally, but as this no doubt produced a very weak paper, there seemed to be a certain balance between paper speed and percentage of groundwood that could not be changed.

The author did not state how the cost of power was estimated. It was true, of course, that the grinders, which were the machines using the largest amount of power, usually obtained it from hydro power, but in the paper mill proper a large amount of by-product power was generally obtained from the process steam. From cases that had come under Mr. Anderson's observation, widely varying estimates had been used for this power. In general it might be stated that no more than 10 per cent should be charged to power when it was extracted from process steam.

The author stated that approximately 40 per cent of the conversion cost was represented by steam and power. It would be interesting in this connection to know whether any estimates had been made by the News Print Service Bureau, in regard to the reduction of power costs by means of higher steam pressures. In many cases the savings that might actually be accomplished in this way were extremely great.

Harold V. Coes[3] wrote that the paper showed clearly the benefits that could be obtained by setting up standards of control and of production, based upon careful and painstaking investigation and research, thus enabling each plant in an industry to measure its performance with the other plant and with the standards of performance set up for industries as a whole; and that the newsprint industry had set an example to other industries that might well be followed.

It was not quite clear to Mr. Coes upon what minimum basis the standards of performance had been set. It was conceivable that one manufacturing unit might be so small as compared with the average plant or the largest plant in the group, that this small plant's performance would not enable it to get some of its costs down (steam generation, for example) as compared with the others. In other words, how did the marginal producers show up in these comparisons?

Most American industries today, with few exceptions, were suffering from a lack of vital, authentic statistics covering their industry that would permit the individual managers to so regulate the operation of their plants as not to over or under produce and to operate their plants on a more even keel, with lasting benefit not only to the labor employed but also to the community served and to the stockholders.

Until a recent Supreme Court decision had clarified the atmosphere, our Government had blocked any progress that might have been made along broad, constructive lines, though why it should have denied to manufacturers the right to collect basic economical data collectively for the conduct of the manufacturing industry, when it had assisted the agricultural industry to obtain and disseminate the same form of vital statistics, was hard for an intelligent man to understand. However, the court decision just referred to held out hope that better things could be looked for in the future, and the author's able presentation of the case for the newsprint manufacturers was an encouragement to all those who were confronted with similar problems and ideals in other industries. He hoped there would be more of such papers for other industries as time went on, for they were milestones in the path of industrial management and progress.

The author, in closing, said that in regard to Mr. Anderson's question as to the economy in the life of felts, there was practically nothing that could be standardized in this respect. The felts or the equipment going on to the paper machine were constantly being improved, consequently the only really adequate comparison that could be obtained was that between mills with modern machines of various sizes on this standard basis.

This was also checked with the cost of felts per ton of production, per ton of paper. These figures were also available to the mills coöperating in the exchange of conversion costs, conversion cost meaning only the manufacturing cost, and representing about 50 per cent of the total cost.

Speeding up was the tendency of the modern newsprint mill, but if applied to old machines it could be closely checked by the operating report shown in Fig. 5. In other words, as the machine was speeded up, the theoretical production upon which the efficiency of the machine was based naturally became higher. But if it was found that the "broke" losses or losses in paper that had to be reworked went up, it was safe to assume that perhaps the machine was being speeded up too much.

The cost of power was measured, not estimated.

Mr. Coes referred up the standards set. These standards had been worked out through experience in the newsprint industry. The felt and wire standard was based on the square footage or poundage and the production per square foot per pound, which had been found to be the best of any standard available.

The standard in the machine operating report was a percentage basis, and the normal or best production of any particular machine (it was divided by machines first) was based on the standard theoretical formula of the speed of the machine, the trim, and basic weight to determine how much the machine in question could actually make if operated under ideal conditions for twenty-four hours in the day.

The reports described provided the managers with information that they must naturally use, and were of a type that forced not only the management to keep on their toes, but the workers as well.

[2] General Engineering Division, Westinghouse Elec. & Mfg. Co., South Philadelphia Works, Philadelphia, Pa. Assoc-Mem. A.S.M.E.

[3] Belden Mfg. Co., Chicago, Ill. Mem. A.S.M.E.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AIR MACHINERY

The Hele-Shaw Beacham Air Compressor

OVER twenty years ago Dr. Hele-Shaw invented a rotary air pump, and attempts were made later to adopt the same principle for an air compressor. Difficulties delayed the accomplishment of this purpose, however, until certain features were introduced which are said to have made it possible to overcome them.

The compressor is of the rotary type with a central fixed cylindrical valve round which the cylinder body rotates. Pistons working in the cylinder body are forced inward by an eccentrically running ring, a so-called floating ring. This ring rotates freely with the cylinder body although not fixed to it, and the design is such that a very high speed of rotation is possible, the common speed being 1000 r.p.m.

The essential feature of the new compressor is the impregnation of the incoming air with oil, the oil serving to lubricate both the central valves and pistons. The oil-saturated air is cooled by a special water jacket and the oil is then extracted from the air by a device which has been called an eliminator.

There are four cast-iron cylinders, two of which are low-pressure and two high-pressure, the sides of the cylinders having slots cut in them for the gudgeon pins to work. The center of the casting is bored to fit the central valve. In the valve three narrow grooves are cut which are connected by $^1/_8$-in. holes to an oil hole in the valve supplied with oil under pressure from the eliminator. The valve is a most intricate casting, but no trouble has been encountered in its manufacture.

The two coolers, intercooler and aftercooler, are formed in one aluminum casting and differ greatly from the usual type of coolers of the pipe form. They are formed in one disk and the cooling of the air is obtained by water passing through the space between the cooler and casing.

The object of this is to remove all the oil which is in the air, and to supply it to the central valve, thus forming an oil seal and making the valve airtight. The oil-saturated air enters the eliminator from the aftercooler. It first passes through the baffle plate with $^3/_8$-in.-diameter holes, and then enters a nest of small vertical wires $^1/_{16}$ in. in diameter. This nest is of square section, measuring $4^1/_2$ by $4^1/_2$ by 12 in. long, and contains in all about 800 wires. The particles of oil in the air strike these wires, on which they collect, and passing down them enter the oil sump, from which sump the oil is delivered through a small-bore pipe and filter to the central valve. The object of the small-bore pipe is to throttle down the oil pressure, as it is found that 3 lb. per sq. in. is quite sufficient to provide satisfactory sealing of the valve. Leaving the nest of wires, the desaturated air leaves the eliminator, on which is fitted a non-return valve. Two oil-level test cocks are fitted at the exit end. By means of these the correctness, or otherwise, of the oil level in the sump can be determined. At the lowest point of the sump a drain cock is provided for drawing off any water that may have accumulated.

"Venturi tube" is the name which, owing to its shape, is given to the suction pipe. The air enters through a perforated cover and passing along the converging part of the tube increases its velocity and thus decreases its pressure until it reaches a neck. On entering the diverging portion, it begins to regain pressure, the diverging portion of the tube being made gradual to prevent eddies being formed, as such eddies would cause a lower final pressure with a resulting lower volumetric efficiency. A pipe connects the neck of the tube to a point on the end cover, which is about $1^1/_2$ in. from the bottom of the casing pump. Owing to the reduced pressure at the neck, oil in the casing above the $1^1/_2$-in. level is drawn through the oil pipe to the tube, where it mixes with the suction air and passes to the cylinders.

The torque curves for the low-pressure or first-stage cylinders, and the high-pressure or second-stage cylinders for this type of compressor, when combined, show a very even torque for the machine. In practice there is practically no vibration, which bears out the resultant torque curve. It was found that a coin could be balanced on edge, and a pencil stood on its end, on the casing when the compressor was running at 1000 r.p.m.

Fig. 1 shows graphically the results of tests at 700 r.p.m. to a base of delivery pressure.

It is seen that the volumetric efficiency is practically constant for delivery pressures up to 140 lb. per sq. in. gage, and is much higher than that obtained with the usual type of compressor. It appears that the cylinder clearance space is full of oil at the end of stroke, and that the small loss of efficiency is due to the air being heated by contact with the valve during the suction stroke. Another reason for the high volumetric efficiency, though of small consequence, is the fanning action of the air during the suction stroke. When the ports open, the air molecules, due to centrifugal force, fly toward the piston, and a slightly higher pressure exists there than at the inlet port. Thus a greater quantity of air is drawn in than would fill the stroke volume if the compressor were non-rotary. The gain may be only small, but "every little helps."

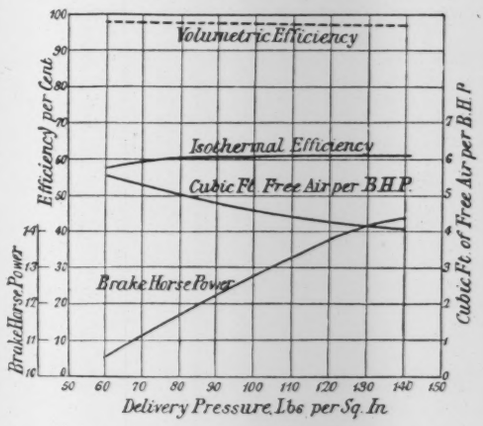

Volumetric Efficiency
Isothermal Efficiency
Cubic Ft. Free Air per B.H.P.
Brake Horse Power
Efficiency per Cent.
Brake Horse Power
Cubic Ft. of Free Air per B.H.P.
Delivery Pressure, Lbs. per Sq. In.

FIG. 1 CURVES FOR THE HELE-SHAW BEACHAM AIR COMPRESSOR

Isothermal efficiency is practically constant over the whole range of delivery pressures. The falling off at the lower pressures is due to the air being compressed above the delivery pressure in the second-stage cylinders, owing to the action of the mechanically operated valve, and then being released suddenly. It will be seen, however, that although the ports in the valve were set for a delivery pressure of 120 lb. per sq. in. gage, the loss of work due to discharging the air over a large range of pressures is not appreciable.

It is claimed that this compressor has almost perfect balance at all speeds owing to the fact that the reciprocating movement between the cylinder and piston is merely relative and not absolute. The oil employed for lubrication acts not only as a packing for the pistons but as a seal for the central valve. The article also calls attention to the low temperature of delivery of the compressed air owing to the oil-saturation effect, and the high volumetric efficiency at all pressures due to the small clearance and even more so to the oil filling the clearance spaces. (Dr. H. S. Hele-Shaw and T. E. Beacham in *Engineering*, vol. 120, no. 3123, Nov. 6, 1925, pp. 588–589, 9 figs., *d*)

ENGINEERING MATERIALS

The New French Rail Specification

IN THE new French specification the railroads are allowed to specify the process to be followed in the manufacture of the rail steel, i.e., either basic or acid bessemer or open-hearth. The specification makes no stipulation to the reference of the casting of the ingot, but it says that in no case shall the ingot have a section less than twenty times that of the rail, and no ingot shall be placed in a horizontal position previous to complete solidification. The

top discard from the rolled ingot is to be such as to make it possible to cut from a length of rail 27 1/2 in. for the impact test, and is never to be less than 12 per cent of the total weight of the ingot. At the opposite end of the rolled ingot the discard is to be such as to permit of cutting out a piece 11 3/4 in. long for making tensile-test specimens.

Cold straightening of the rails is to be carried out as usual by gradual pressure. Certain rail fractures appear to have been traceable to injuries received by the metal during cold straightening, which the *Revue Générale des Chemins de Fer* points out is quite possible, in view of the local strains to which the steel is subjected in the course of the operation. Railway engineers become aware of such injury only when it is apparent on the surface. In drawing up the specification it was not found possible to enter into details on this point, and researches are to continue with a view to effect the detection of these internal injuries if and when produced; the investigations will also include an examination of cold-straightening operations and may lead to the prohibition of certain machines and processes.

An important innovation is the provision of one impact test per ingot. For this the tup must weigh 300 kg. (660 lb.) the weight of the anvil is to be not less than 10,000 kg. (about 10 tons), the height of fall is to be equivalent in meters to the weight of the rail in kilograms per meter multiplied by the following coefficients: 0.10 for the 65 kg. per sq. mm. grade, 0.095 for the 70 kg. per sq. mm. grade and 0.090 for the 80 kg. per sq. mm. grade. The length of rail to be tested measures 0.700 m. (27 1/2 in.) and it is to be supported, head downward, on two supports rounded on the top placed 0.500 m. (19 5/8 in.) apart between centers, rigidly fixed to the anvil. A round notch must be previously cut by a 100-mm. (3 15/16 in.) milling cutter in the rail head, in the middle of the test specimen, the depth of the notch being two-fifths the height of the rail head. The test specimen must withstand this test without breaking. The standard tensile and hardness tests are also required. The minimum tensile stengths are those quoted, namely, 65, 70, and 80 kg. per sq. mm., the minimum elongation on 100 mm. (3 15/16 in.) being for the three grades 10, 9, and 7 per cent, respectively. As compared with one specimen per ingot tested under impact, the tensile test is to be carried out on every heat only, and as above stated, the tensile-test specimen is cut from the part of the rail corresponding with the foot of the ingot, while that for the impact test is taken from the end corresponding with the top of the ingot. No special stipulations are made with regard to the ball hardness test, nor, apart from the impact test, are any tests required intended to reveal defects traceable to segregation in the ingot. (*Engineering*, vol. 120, no. 3124, Nov. 13, 1925, p. 601, *g*)

FOUNDRY

Hydraulic Washing of Castings

DESCRIPTION of an installation in the heavy-casting foundry of the Allis-Chalmers Manufacturing Co., Milwaukee, which is claimed to reduce the work of cleaning enormously. Thus, it is stated that, for example, where it took 600 hr. to clean a cast-iron turbine runner by the old process, the same job can be completed in 14 hr. by hydraulic washing.

The washing plant is a structure 34 ft. by 45 ft. in floor plan by 20 ft. high, built of reinforced concrete. The doors are made watertight and are operated by a 2-hp. electric motor. The roof is made in three sections, one telescoping over the other and moving in a horizontal plane in the direction of the main crane bay. Each section is separately operated on tracks along the side walls by a separate 2-hp. motor controlled by push buttons from the operator's house. By this arrangement the roof sections can be rolled back and the end doors opened, thus giving the three overhead electric cranes free access to the entire floor space of the washing room. There are also two turntables, a large and a small one, with dummy tops on the small turntable. Screen-protected electric reflectors are so arranged as to have the work on the turntables well illuminated.

Pressure water at 425 lb. to the square inch for the nozzles is obtained by a 4-in. 6-stage electrically driven centrifugal pump with the motor remotely controlled from push-button stations in the operators' house. An automatic float switch is also provided which either prevents the motor from being started or shuts it down in the event of low water in the tank. A further safeguard is provided in a switch attached to the door leading from the first floor of the operators' house into the washing room whereby the pump motor cannot be started unless this door is closed. If the door is opened when the motor is running, the latter is immediately shut down.

The water is controlled by starting and stopping the pump. A feature of this installation is that no valves are provided between the pump and the nozzles, the only control being that of starting and stopping the pump. The reason for this is that if valves should be closed and the motor continued to operate, the work done in churning the water in the pump would cause excessive heating, which would result in damage to the unit.

In operating the end doors are first opened and the roof rolled back. The crane then loads the turntables and the operator presses buttons to close the doors again and slide the roof panels back in place. The lower door in the operating room is then closed and the pump started. One operator directs the stream of water on the work on each turntable and has under his control the rotation of the turntable on which he is working.

Castings such as gears and flywheels should be allowed to cool down to about 200 deg. fahr. before washing. Less complicated castings may be washed at a higher temperature, while the general run of castings can go to the hydraulic cleaner at very nearly the temperature at which a man with a chipping hammer would be able to work on them.

The foundry is clean and free from dust at the cleaning end because of the absence of chipping. The work is less laborious than hand cleaning. (Rogers A. Fiske in *The Iron Age*, vol. 116, no. 21, Nov. 19, 1925, pp. 1383–1385, illustrated, and E. C. Barringer in *Iron Trade Review*, vol. 77, no. 21, Nov. 19, 1925, pp. 1267–1269 and 1318, illustrated, *d*)

Casting in Permanent Metal Molds

DESCRIPTION of a process for making intricate castings in permanent molds. The process of making molds is referred to as the "plastic process," and it is claimed that by it castings are made to almost exact size and form. The details of the process are not announced. It is stated, however, that the process relates to the casting of steel and nickel alloys to sufficiently close dimensions so that only grinding and finishing are required to produce a complete die for stamping or a mold for forming materials. It is also stated that a material has been found which will withstand the high temperature of molten steel or nickel, producing a casting entirely free from scale, and that there is no warping of the surface of the mold or of the metal. By this process castings for use as molds or dies are made having a surface requiring the removal of only 0.0025 in. to 0.003 in. for finishing.

The permanent molds used in connection with the plastic process are usually made of an iron-silicon alloy similar to a well-fluxed fine-grained cast iron. (M. S. Clawson in *The Iron Age*, vol. 116, no. 20, Nov. 12, 1925, pp. 1310–1313, *d*)

FUELS AND FIRING (See also Railroad Engineering: Replacement of Oil by Powdered Lignite on Locomotives)

Oil Research at the University of Birmingham, England

IN CONNECTION with the investigations which are in progress at the university on the extraction of oil from coal and other bituminous matter, a high-pressure chamber has been completed. The chamber is being equipped with delicate apparatus, some of which has been made by the mechanical-engineering department of the university. There is a special bomb-proof shelter for experiments. (*The Times Trade and Engineering Supplement*, vol. 17, no. 384, Nov. 14, 1925, p. 221, *g*)

British Fuel Research Board

REVIEW of five years' work. One of the important subjects investigated by the Board was that of producing a smokeless fuel by carbonization at low temperature, because it was along the lines of low-temperature carbonization that the best prospect of obtaining the desired supplies of oil seemed to lie. The investigation

was carried out by means of installations erected on a scale equal to that of practical units. Furthermore an investigation has been made into the various coal seams with a view to determining the constituents of a seam and their distribution therein. The Board has also done important work with the object of standardizing methods of sampling and analysis, and has introduced the Gray-King assay apparatus whereby considerable light is thrown on the component parts of a coal as they appear at moderate temperatures before they have gone any great length toward being resolved into their elementary constituents.

A branch of the Board's work that may come to have particular importance is that of the production of power alcohol. The Board has published several reports on its work on this subject, and is understood to have been instrumental in obtaining the relaxation of the fiscal regulations that have handicapped the chemical and other industries by which alcohol is used. Under the direction of Sir Frederic Nathan, several different methods of obtaining alcohol from cheaply grown vegetables or from waste products have been and are under investigation. However, the policy of avoiding any possible overstatement of the value of results obtained —shown so conspicuously in regard to the investigations into low-temperature carbonization—has been adopted most scrupulously in the case of investigations into power alcohol. At the moment the investigations have not developed the means of any great practical step, and Sir Frederic Nathan's reports leave no doubt on this subject. At the same time, the possible importance of a successful result is so great that it cannot be questioned that the continuance of these inquiries is a matter literally of national importance for Great Britain. It may, indeed, be said that its importance is imperial rather than national, seeing that in many parts of the empire the means of growing crops suitable for being made into alcohol are present to an extent to which they never can be in England itself. (*The Times Trade and Engineering Supplement*, vol. 17, no. 3823, Nov. 7, 1925, p. 199, *g*)

The British Fuel Research Board

THE work done by the Board in connection with the gas industry began with the recommendations on which the Gas Regulations Act of 1920 were framed and the "therm" adopted as unit of charge. One consequence of this Act was the possibility of increasing the make of gas per ton of coal and its aggregate thermal value of steaming during carbonization, at the expense of its calorific value per cubic foot. The Board has reported on the results of steaming with various types of coal, and has been able not merely to give an accurate statement based on large-scale work of the results obtained from each of them under given conditions of steaming, but also to ascertain the optimum conditions that can be obtained by modifying the treatment. The report summarizes, in a table, some of the main results of treating eight different coals giving for each coal the make and quality of gas, its thermal efficiency, and the yields of tar and sulphate of ammonia. Special researches have been made on the production of gas of high calorific value, the effect of introducing air during carbonization, and other subjects. Experiments are in progress with the object of determining the distribution of temperature in coal as it passes through vertical retorts, and the states of carbonization reached at various levels.

An incidental result of these investigations, the full importance of which may not have been recognized, was obtained when, on relining the retorts, fireclay plugs were substituted for the cast-iron linings and shutters of the sight holes. The total heat value of the fuel gas previously used for heating the setting varied from about 10 therms and 20 therms per ton of coal carbonized. The substitution of the fireclay blocks for the cast-iron fittings effects a saving of no less than 7 therms; an extraordinary result, which, as the report remarks, shows to what extent economy might be effected in practice by paying due attention to insulation and the reduction of heat losses by radiation, etc.

The station is heated by a Humphreys & Glasgow water-gas plant, on which observations have been made. Advantage is taken of the considerable number of cokes produced at the station in large-scale carbonization experiments to try them both in the water-gas plant and in the producer plant with which the station is equipped. These trials have thrown light on the differences in gas cokes in respect of their suitability for making water gas and producer gas. The differences appear to be due mainly to the variation of the nature and amount of the ash content, and the effect of ash and clinker on the refractory linings of the generator is being studied.

The second of the two main lines of investigation for which the Fuel Research Station was started deals with methods of low-temperature carbonization. These methods offer, as the report remarks, a possible, and probably the only possible, means of so treating the coal as to obtain a source of oil fuel and motor spirit together with a solid smokeless fuel that can be burned in any domestic grate. Oil fuel is now used in the Navy to the almost total exclusion of coal, and is being used increasingly in internal-combustion engines and otherwise both in the mercantile marine and on land. Motor spirit, moreover, is in increasing demand both for road and air transport, though even now mechanical road transport has not nearly reached the extended use that is made of it in the United States. The economic burden of having to import practically all the country's oil fuel and motor spirit, and the direct and indirect cost and mischief of the pollution of the atmosphere by the smoke of the domestic hearth, make the practical solution of the problems of low-temperature carbonization an object of the highest importance if such solutions can be found.

The Board continues to adopt the cautious attitude that it has taken throughout about the prospects of founding such an industry. In Sir George Beilby's last report on the subject he stated that, while a final answer could not be given to the question of whether such an industry could be established, it seemed likely that an answer would be reached before long, and that some ground existed for expecting that the answer on the technical side would be affirmative. Further progress has undoubtedly been made since this opinion was expressed, but the report still lays stress on the difficulties that remain to be solved, and the subsequent economic questions that would arise if methods for utilizing coal not at present in general demand were put in general practice, and the price of such coal was therefore raised to the level of other coal. The question is still therefore not definitely answered, and it appears to be extremely fortunate that the Board's interpretation of the results that have been obtained remains as conservative and prudent as it has been hitherto. Meanwhile the experimental investigation of the subject proceeds vigorously, and the Board is undertaking to investigate and report, without charge, on the technical efficiency of suitable plants. (*Engineering*, vol. 120, no. 3124, Nov. 13, 1925, pp. 596–597, *g*)

Theory of Spontaneous Combustion of Coal

THE author believes that spontaneous combustion of coal is due to oxidation of combustible matter by free oxygen carried in solution by a liquid, the oxidation taking place only as, when, and at the place where this oxygen is released from solution by the evaporation of the liquid. Also this oxidation takes place to some degree irrespective of the condition of the combustible, which may be lump coal, coal dust, straw, wheat flour, coke, etc. But as the speed of oxidation is directly influenced by temperature, it follows that spontaneous combustion only becomes noticeable or serious in cases where the resulting heat cannot escape as fast as it is generated.

The author cites a case (Castle Gate No. 1 Mine) where an old dump contained bony coal and track cleanings generally. In winter when snow fell upon this old dump the snow was soon melted by the heat of the dump, which was comparatively warm at all times. Within 48 hr. thereafter little blue flames were in evidence on the surface of the pile. Few of the gas feeders were sufficiently constant to maintain a steady flame at any given point, but shifting emissions of gas were ignited one by another, resulting in a continuous popping and apparent running about of the flames. According to the author's theory, the melting snow carries its dissolved oxygen down into the pile. So long as the water remains in liquid form it holds the oxygen intact, but capillarity soon causes this water to spread out to an extent directly dependent on the fineness of the material in which it reposes. Evaporation soon begins and concentrated oxygen is released. If the heat generated by the absorption of this oxygen is not dissipated as fast as created,

the resultant rise in temperature speeds up the whole reaction until all available oxygen has been consumed. If the temperature of the combustible has not been raised to its ignition point in an atmosphere of free air before the exhaustion of water supplying oxygen, all heating subsides until there is another snow storm.

One of the consequences of this theory of spontaneous combustion is that sprinkling coal mines with fresh water may be a very poor practice indeed, and might account to some extent for the violence of dust explosions occurring in mines. (C. P. Crawford, Combustion Engr., Salt Lake City, Utah, in *Modern Mining*, vol. 2, no. 10, October, 1925, pp. 323–324, *g*)

Low-Temperature Carbonization in Revolving Retorts

THE problem of low-temperature carbonization seems very simple at first sight. In gas works and coke ovens coal is carbonized at a temperature of about 900 deg. cent. without the slightest difficulty. It does not seem that it should be so difficult to do the same thing at a few hundred degrees less, and yet many millions of dollars have been consumed in experimentation, with thus far rather scanty returns. If the difficulties accompanying low-temperature carbonization are analyzed they can be summed up as resting with the heat-resisting property and small heat conductivity of the coal, which makes it imperative to treat coal either in comparatively thin layers or in continuous motion. Carbonizing in thin layers means a small output in proportion to the area of the heated-retort surface, and requires a great number of units for carbonizing a given tonnage and much labor for the intermittent method of operating. Carbonizing the coal in motion is always carried out by continuous operation, but the formation of coke is then difficult, for if large lumps of coke are formed there occurs an obstruction in the mechanically driven coke discharge which upsets the whole operation. Several plants operating with revolving retorts, no two of the same design, have been installed in Germany, and the author describes the one erected at the blast-furnace works at Gelsenkirchen in Westphalia.

Run-of-mine coal is used. The retort is made of plates of special heat-resisting steel 18 mm. (11/16 in.) thick, riveted together. It is 65 ft. long and has an internal diameter of 8 ft. The retort is supported on rollers in an inclined position, the drop amounting to about 5 per cent, or approximately 39 in. between feed and discharge ends.

The details of the coke discharge, which is the most important part of such a retort, are described and illustrated in the original article. The retort makes one revolution in 3 min. 25 sec. and is surrounded by a heating furnace from which it projects about 39 in. on each end, so that a length of 59 ft. is heated. The furnace forms at right angles to the retort five combustion chambers, into which project the burners. The sixth chamber nearest to the discharge end of the retort is not heated and is connected by a flue to the chimney. The burners receive blast-furnace gas and the arches of the combustion chamber on the side toward the burners up to the center of the oven consist of solid firebrick, while the other half of the arches from the center to the side of the furnace opposite to the burners is built of brick checker work to allow the combustion products of the burner flames to pass upward into the chambers surrounding the retort. This arrangement is made to prevent the tips of the flames from touching and overheating the retort, which is thus completely protected from direct heat.

The original article gives a diagrammatic sketch of the gas-handling machinery indicating the flow sequence. The gas leaves the tower at a temperature of 15 to 20 deg. cent. (59 to 68 deg. fahr.) and goes to the gasoline-extracting plant. It is washed there with tar oil in two towers connected in series and filled with wooden packing. The low-temperature tar collected in the by-product plant does not separate easily from the water with which it is mixed, but forms an emulsion of a consistency depending upon the amount of free-carbon-dust content in the tar. This emulsion might be easily separated by applying heat to evaporate the water, but in the course of this operation part of the light-oil content in the tar is driven off. To avoid this the tar-dehydrating plant was placed in the same building with the gasoline plant. The emulsion is drawn from the tank by a pump and circulated through the heat exchanger. It passes through the dehydrator, which the tar leaves at the bottom practically free of water and at a temperature of 110 to 120 deg. cent. (120 to 248 deg. fahr.). Vapors driven off by the dehydrator after passing through the heat exchanger and the water cooler collect in the separator where light oil and water are separated and overflow continually, the former being conducted to the light-oil collecting tank.

The semi-coke is quenched, dried, and ground for use in industrial furnaces equipped for pulverized-fuel firing. In separating the coke by means of a coke grip with prongs 1¼ in. apart, 42.6 per cent of lumps can be recovered, while 57.4 per cent remains in the form of breeze and dust. The coke is very soft and can be disintegrated by hand without great effort. Compared with metallurgical coke, the semi-coke does not show an open cell structure. As run-of-mine coal is used, the coke contains impurities. All these conditions make it impossible to use it for any metallurgical purposes except in gas producers and in the ground form for pulverized-fuel firing. Briquetting of the semi-coke is not a paying proposition as a rule.

The low-temperature tar condensing in the by-product plant has the usual properties. Dust deposited in the dust catchers combines with the tar of high boiling point which condenses upon the inner surfaces of the dust-catcher shell and forms a soft pitch. This pitch can either be distilled in a tar still or can be carbonized in a retort, yielding a coke with less than 4 per cent of ash that is suitable as a raw material for the manufacture of carbon electrodes. It is free from ammonium chloride and does not affect the shell of the tar still. To reduce the output of the rather undesirable pitch, which is difficult and expensive to handle, it is proposed to use a dust catcher with walls insulated by a heat-protecting jacket and conduct either exhaust steam or hot waste gases from the chimney flue through the jacket space to prevent the tar from condensing upon the dust-catcher shell as much as possible.

The physical and chemical properties of the light oil and motor spirit are given in the original article. The motor spirit resembles ordinary gasoline in composition only slightly. There is no need to wash the light oil with sulphuric acid for use in internal-combustion engines. It suffices to wash the light oil with caustic soda lye to remove the sulphureted hydrogen which it holds in solution. Besides removing the sulphur, the caustic soda combines with the phenols contained in the light oil and is used afterward to manufacture pure carbolic acid and valuable cresylic acids.

The gas is of interest because of its high calorific value (644 B.t.u.) and complete absence of hydrogen. It is claimed that the profit from the plant is enough to pay for it in two years. (A. Thau, Halle, Germany, in *The Blast Furnace and Steel Plant*, vol. 13, no. 11, November, 1925, pp. 434–441, 8 figs., *d*)

HEATING AND VENTILATION (See Thermodynamics: Dissipation of Heat by Bare Iron Pipe)

INTERNAL-COMBUSTION ENGINEERING

A Thermodynamic Analysis of Gas-Engine Tests

THE object of this investigation was to apply a rational thermodynamic analysis of the constant-volume, or Otto, cycle to test results obtained from an engine operating on such a cycle, and from a comparison of results from theory and experiment to discuss the factors which prevent the actual engine from attaining the ideal performance as defined by the thermodynamic analysis.

Furthermore, by a combination of laboratory data and thermodynamic theory it was possible to throw considerable light on such processes as the rate of reaction in the cylinder of the engine, and the magnitude of the heat losses during different parts of the cycle.

The thermodynamic theory of this investigation was limited to a discussion of the effects of dissociation, mixture strength, compression ratio, and character of fuel on the performance of the ideal cycle.

The theoretical discussion is based upon a thermodynamic analysis of the problem of gaseous combustion developed by G. A. Goodenough, Mem. A.S.M.E., professor of thermodynamics in the University of Illinois.

The experimental work was done in the Mechanical Engineering Laboratory on an engine running on the constant-volume, or

Otto cycle at constant load and speed, with various compression ratios and mixture ratios, using illuminating gas and hydrogen as fuels.

While the paper is very interesting, it is not suitable for abstracting. Only the conclusions are therefore reproduced below.

1 A method has been developed for calculating the ideal adiabatic Otto cycle. This method gives results which differ from the actual cycle by amounts which can be accounted for by the various engine losses.

2 A method has been developed for estimating the progress of the explosive reaction during the expansion stroke, and for determining the time at which the reaction is practically complete.

3 The thermal efficiency of the engine tested at first increased with increasing air-gas ratios, finally attaining a maximum; and then decreased as the air-gas ratio increased.

4 The thermal efficiency of the engine tested at first increased rapidly with increasing compression ratio, and tended to reach a maximum value at a compression ratio of about 6.00 to 1. If the compression ratio was increased beyond this point, the thermal efficiency decreased, and the operation of the engine became irregular.

5 The curves of ideal thermal efficiency and indicated thermal efficiency obtained are of the same shape and lie practically parallel, substantiating the accuracy of the theoretical analysis of the cycle.

6 The effect of dissociation with the particular fuel used was found to be very slight. The dissociation at the calculated maximum temperature in most cases was zero.

7 The theoretical analysis gives results which agree very well with the air-standard efficiencies when the cycle is based on the operation with pure dry air.

8 The effect of different fuels on the thermal efficiencies was found to be slight. However, the two fuels used were somewhat similar in character, and therefore no pronounced difference would be expected.

9 It has been definitely established that the reaction in the cylinder is not complete at the instant when maximum pressure and temperature are attained.

10 The continuation of the reaction occurring late in the stroke is sometimes caused by slow combustion, and sometimes by the fact that the gas in the valve pockets and other outlying parts of the combustion space is not ignited until late in the stroke.

11 The general tendency of the reaction velocity is to decrease with weaker fuel mixtures. From the results of the tests herein reported, no definite effect of compression ratio on reaction velocity is evident.

12 The heat loss during compression, explosion, and expansion decreases rapidly with increasing air-gas ratios, due to the lower gas temperatures attained with the weaker mixtures.

13 Compression ratio has less effect on the heat loss from the gas than does the mixture ratio. (Crandall Z. Rosecrans and Geo. T. Felbeck in *University of Illinois Bulletin*, vol. 22, no. 50, Aug. 10, 1925, which is also Bulletin No. 150 of the Engineering Experiment Station, 95 pp., 27 figs., *tA*)

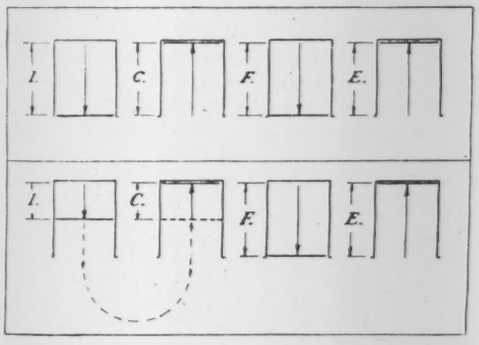
A Double-Expansion Internal-Combustion Engine

DESCRIPTION of an engine invented by W. Brown, of Sydney, Australia. Fig. 2 represents the cycle of an ordinary four-cycle motor where *I* represents the intake stroke, *C* the compression stroke, *F* the firing and expansion stroke, and *E* the exhaust stroke. Fig. 3 may be said to represent the cycle of operations in the Brown double-expansion motor. At the commencement of *I*, the inlet stroke, the charge of gas is drawn into the cylinder from the induction piping and the piston traveling on the downward or outward path continues to draw the charge into the working chamber until it has reached a point approximating in midstroke. At this point the inlet valve closes and the third valve is then opened, putting the working chamber or cylinder into communication with the auxiliary chamber or reservoir mentioned above. This third valve remains open during the completion of the inlet stroke of the piston, and until the piston gas again reached mid-position on the compression stroke, when the valve closes and the remainder of the stroke is completed and compression takes place with the cylinder sealed as in the ordinary four-cycle engine.

Firing takes place at the end of the compression stroke, and the expansion of the gas acts upon the piston until it reaches its complete full stroke, when the exhaust valve opens and the products of combustion are forced out through the exhaust pipe by the piston sweeping back on its fourth stroke, and the cycle of operations is again passed through. It can be seen that this cycle gives a ratio of double the length of expansion to compression.

The object of opening the third valve is to prevent the formation of a vacuum in the cylinder when the inlet valve closes, as this would probably cause several undesirable happenings, such as the drawing of lubricating oil past the piston rings into the working chamber and consequent fouling of plugs, the opening of the inlet valve, unless a very heavy spring were fitted to it, or the opening of the exhaust valve, with a consequent drawing of waste gases into the working chamber. By putting the cylinder into communication with the auxiliary chamber all these troubles are avoided, and at the same time the engine operates approximately on the amount of charge drawn in during the first half of the inlet stroke.

Actually the mixture in the balancing or auxiliary chamber becomes saturated with gasoline vapor, and, owing to a certain amount



FIGS. 2 AND 3 ABOVE: CYCLE OF A CONVENTIONAL 4-STROKE CYCLE ENGINE; BELOW: CYCLE OF THE BROWN DOUBLE-EXPANSION ENGINE

of swirling taking place between the first charge drawn in at the commencement of the inlet stroke and the mixture drawn in from the chamber, a well-mixed explosive charge is obtained with a much more thorough amalgamation of the gasoline and air than can be obtained through any form of carbureting device alone.

It was thought at first that, after a short period of running, the balancing chamber would become supercharged with gasoline, but it was found in practice that actually the mixture in the chamber contained no surplus gasoline, and this no doubt is mainly due to the fact that it becomes heated up to approximately the working temperature of the cylinder, keeping the gasoline in a well-vaporized condition.

For test purposes an experimental motor was arranged with a movable crankpin working in a long crank web proportioned so that the engine could be run as an ordinary four-cycle motor of 6-in. bore by 7-in. stroke or could be altered to run as a double-expansion motor of 6-in. bore by 14-in. stroke. The third valve was operated by a push rod which could be slipped into position when the machine was to be operated on the double-expansion principle.

It was found possible, when the engine was working on the expansion principle, to obtain an increase of 19 per cent in the brake-horsepower output with a fuel economy of 17 per cent while the thermal efficiency was increased by 11 per cent. A new engine was then built in which, in addition to double expansion, triple and quadruple expansion can be obtained. In the various tests made, the greatest economy was obtained with an expansion of 3.3 to 1. It is stated that in practical work an economy of 59 per cent and over has been attained, and that no trouble has been experienced from burning exhaust valves, overheating, etc. In tests it was found that the fuel used per hour was 0.475 lb. per indicated horsepower with a thermal efficiency of 34.8 per cent. The inlet cooling-water temperature was 20.5 deg. cent. and the outlet temperature 43.3 deg. cent. Data of another test conducted in Oakland, Cal., on Feb. 28, 1924, are also reported. This was with an engine of 8-in. bore 10-in. stroke, running at 360 hp.

and rated at 10 hp. but delivering 10.53 hp. (*Gas and Oil Power*, vol. 21, no. 242, Nov. 5, 1925, pp. 25–27, 5 figs., *d*)

Commercial Carburetor Characteristics

THE purpose of this investigation was to obtain the performance characteristics of the representative carburetors manufactured in this country, the ultimate object being the determination of possible improvements so that the carburetors will permit the engines with which they are used to develop their inherent capacities and efficiencies. The assumption is made that the manifolding will be designed efficiently and not impair the quality of the mixture leaving the carburetor. This assumption is necessary because it is impossible to make corrections for the effect of faulty manifolding upon the test data.

The ideal carburetor is one which supplies the engine with the correct mixture (fuel-air) for each condition of engine operation. In order to accomplish this end the carburetor must have the following characteristics: (*a*) It must correctly meter the liquid fuel to the air; (*b*) it must offer low frictional resistance to the air flow; (*c*) it must correct the mixture to meet temperature changes; and (*d*) it must provide mixtures that are suitable for engine acceleration.

By metering is meant the proportioning of the fuel to the air flowing to the engine. The exact value that the ratio of fuel to air (mixture) should assume at any time is dependent upon the mixture required by the engine for the condition under which it is operating at that instant. The ideal mixture is one which is homogeneous throughout and of such a composition as to enable the engine to develop maximum economy, but one which may be suitably altered to permit development of the maximum power when required. The quantitative values that the fuel-air ratio must attain for each condition of engine operation have been determined by previous researches on engines.

Of the twenty-three test carburetors, only four closely approach the above ideal specifications.

Several of the test carburetors furnish fairly satisfactory mixtures only for idling and for low-speed, level-road operation.

Some of the carburetors furnish satisfactory mixtures only for level-road operation at the intermediate speeds.

A few of the test carburetors have characteristics which are entirely the reverse of those that are called for by the ideal specifications.

Approximately 40 per cent of the carburetors meter erratically; that is, they do not at all times furnish the same mixture for the same operating condition.

The majority of the carburetors do not adequately enrich the mixture for full-load operation, and as a result they have to be so adjusted that uneconomical operation ensues.

With proper care any type of carburetor can be designed to meter the ideal mixtures.

Points in the metering of a carburetor causing improper operation depend upon the individual design and may occur at any air-flow rate.

The majority of the commercial carburetors tested most closely approach the ideal specifications at car speeds ranging from 20 to 30 m.p.h. Hence this speed range usually gives the greatest number of miles per gallon of fuel.

Most carburetors are too constricted, and it appears that $1^1/_2$-in. and $1^1/_4$-in. carburetors are more constricted than are 1-in. carburetors.

Any type of carburetor, with care, can be designed to offer low resistance to air flow.

Only 26 per cent of the test carburetors allow the engine to develop its maximum power; 30 per cent of the carburetors are so constricted that they cause a large curtailment of engine power.

The following factors influence the reaction of a carburetor to air-temperature changes: (*a*) Carburetor type; (*b*) air bleeding of fuel nozzle; (*c*) design of fuel orifices; (*d*) number of fuel orifices; and (*e*) method of throttling fuel orifice.

Increasing the air temperature usually causes an enrichment of the mixture, the enrichment usually ranging between 5 and 15 per cent per 100 deg. fahr. (C. S. Kegerreis, Opie Chenoweth, and M. J. Zucrow in *Bulletin No. 21, Engineering Experiment Station, Purdue University*, August, 1925, 115 pp., 84 figs., *ep*)

MACHINE TOOLS

Four-Spindle Horizontal Firebox and Boiler-Shell Drilling Machine

DESCRIPTION of the British-made Asquith machine, said to be capable of a much higher output then the single-spindle machine. To obtain the advantages of the multiple-spindle combination (four spindles are considered to be the most efficient and satisfactory arrangement), the spindles must be capable of a very wide range of adjustment in order that they all operate simultaneously in any position on the surface of the work. Because of this they not only must be capable of being moved in line to a vertical or horizontal position, but they must be provided with individual center and angular adjustment, so that holes truly radial to the circumference of the boiler shell may be drilled.

In this machine the drilling head has vertical traverse up and down the column on accurately machined ways, and is balanced by means of a weight inside the column. This vertical motion is effected by the vertical-traverse screw which is driven from an independent reversible motor located at the foot of the column and controlled by a liquid starter from the operator's platform on the drill side. In fact, the three independent motors driving the table traverse and rotary motion, the traversing motion of the column, and the vertical motion of the drill head are all controlled from the operator's platform by liquid starters which insure the necessary fine adjustments.

The success of a machine of this type depends largely upon its ease of operation. In this case the operator controls the machine from a platform carried by the drill head, and at all times has a close and unrestricted view of the section being drilled. Vertical levers on the right-hand side of the platform operate the liquid starters that control the various power-traverse motions, while handwheels control the entire motions of the drill spindles. The operator has therefore complete control over every motion required in the drilling of the complete firebox and boiler shell from his position on the platform. (*British Machine Tool Engineering*, vol. 3, no. 35, Sept.-Oct., 1925, pp. 304–307, 4 figs., *d*)

An Open Side Planer

DESCRIPTION of the type made by G. A. Gray Co., Cincinnati, Ohio, and exhibited at the Steel and Machine Tool Exposition in Cleveland, Ohio, in connection with the convention of the American Society for Steel Treating.

In order better to withstand severe twisting strains the column has been made triangular in section, this design being claimed to be stiffer than the usual rectangular section because its walls are directly in line with the forces to be resisted and there can be no yielding at the corners. Heavy internal braces are cast integral with the column. The bed of the machine has four vertical walls, is cast solid across the bottom under the gears, and has a heavy brace across the top directly under the cutting tools and the rail. The heavy outer wall of the bed extends up the side of the column to the level of the top of the table so as to support the column as high up and as near to the rail as possible.

The gears and table rack are cut from steel forgings and are helical throughout, including bull gear and table rack. A feature is the design of the bull gear which offsets the pressure of the tools on the work by exerting a side thrust on the table. The tools are usually fed away from the operator so that he can see the surface resulting from the cut, and the bull gear tends to push the table in the opposite direction. This is said to materially decrease the tendency of the table to lift under a heavy cut. To still further reduce it, the bull-gear teeth are designed with a 9-deg. pressure angle, the force exerted being said to be nearly horizontal, eliminating the usual vertical thrust. The tooth form used is also intended to provide maximum action in the arc of recess rather than in the arc of approach, the teeth being of true involute form with long-addendum pinions. It is claimed that the continuous rolling contact obtained is of importance not only in getting fine finishing cuts, but that it assures also steady flow of power for the heavy roughing cuts. The gear train runs in a bath of filtered oil, and the side-thrust bearings of bronze provided on each shaft run in a flood of oil which flows over them from the bearings.

To meet the necessity of planing overhanging castings of awk-

ward proportions, hold-down gibs have been provided not only at the center of stroke, but over the entire length of bed and table. Thus tilting is prevented in any position of the table. The oil pumped to each vee flows over the hold-down gibs, so that they run in a flood of oil, which is regarded as a precaution of practical value inasmuch as the upward pressure on the gib may at times be almost as great as the downward pressure normally exerted on the vees. In removing the table, the gibs may be disengaged from the table without running it off the bull gear. Automatically oiled side-thrust bearings are also provided between table and bed.

The structure of the rail and the knee which supports it is unusual. The knee is a pyramid of cast iron of heavy section. A novel knee lock which can be applied or released from the usual operating position by the use of a single crank, locks the knee to the inside of the column in four places. The clamping effect is balanced automatically so that one clamp cannot be locked without also locking the others. It is claimed that the great clamping pressure available prevents vibration or shifting between the knee and column, and explains in part the heavy cuts which the planer can take without vibration. The clamping effect is applied not only to the front, but at the rear of the knee as well, and at the upper and lower edges of the knee. Adjustment for wear is automatic.

A new feature of this type of planer is the Gray ball-bearing spring counterbalance. A ball-bearing roller is mounted at the right-hand end of the rail at the top, and heavy springs force this roller against the right-hand edge of the column face, thereby keeping the rail and knee snug against the column even when unclamped. This counterbalance is intended to offset the overhung weight of the knee, relieves the rail-elevating screw of bending strains, eliminates cocking and binding, and thus facilitates raising and lowering of the heavy knee and rail. (*The Iron Age*, vol. 116, no. 14, Oct. 1, 1925, pp. 889–890, 4 figs., *d*)

MARINE ENGINEERING (See also Power-Plant Engineering: Marine Mercury-Vapor Boilers)

The Snead Electric Heat-Treating and Annealing Process

DESCRIPTION of a resistance method of electric heat treatment developed by Snead & Co., of Jersey City, N. J. The essential feature of the process is that the expansion of the piece heat-treated cuts off at the proper moment the supply of heat to the piece. The process consists of passing an electric current through the mass of the piece to be heat-treated, the resulting heat being due to its own resistance to the passage of the current, and the temperature being determined by the expansion of the piece under treatment. Because of this the application of the process is confined to pieces having practically uniform cross-section, such as rods, tubes, strips, and sheets.

Among the advantages of the process may be mentioned the speed of heating, the fact that no pyrometers are required during the actual operation, that it can be operated by unskilled help, and that the work while in its heated condition is not exposed to furnace gases and does not absorb them. A good example of the application of the process is the annealing of Admiralty brass condenser tubes. The work is held in a horizontal position and is supported by inclined rails. The expansion of the tube is indicated on a dial having an auxiliary stationary pointer which is set to any desired temperature. The dial is, of course, operated by the expansion of the tube itself. When the moving pointer reaches the auxiliary pointer the primary circuit of the transformer is automatically opened and a bell on the machine sounded. The operator turns the handle to the "off" position and the tube runs down the supports either into a pile or a quenching tank. In the meantime the operator by means of a foot treadle returns the expansion head to the zero position. The uniform temperature does not extend to the ends of the work where they are gripped by the jaws and close to the jaws. While it is possible to treat these ends by special devices, the usual practice is to allow for this and trim the ends after heat treatment where absolute uniformity is required. (Chas. C. Waite, Chief Engineer, Snead & Co., Jersey City, N. J., in a lecture before the American Society for Steel Treating; abstracted through *The Metal Industry*, vol. 23, no. 11, Nov., 1925, pp. 441–443, 4 figs., *d*)

POWER-PLANT ENGINEERING

Marine Mercury-Vapor Boilers

DESCRIPTION of some improvements taken from a British patent specification issued to the British Thomson-Houston Company.

When mercury-vapor generators are mounted on board ship, it is necessary to provide means for maintaining the static head of the mercury feed on each of the tubes when the vessel is pitching and rolling, or both. This specification describes a revolving-tube type of mercury boiler, wherein the static heads of the mercury feed on the revolving tubes are maintained equal. The boiler shown in Fig. 4 has three revolving tubes. *A* is the mercury-vapor condenser and *D* is the sump for the condensed mercury vapor. The tubes *Q* and *E* communicate with the supplementary chamber, which is divided by partitions into three compartments *G*, *H*, and *K*, which are connected by the feed pipes *P*, *O*, and *N*, respectively, to the revolving tubes *S*. The tubes *R* lead through the partitions *F* to the central point of the compartments *G*, *H*, and *K*. With the ship swung into the position shown, the surface of the mercury in the compartment *D* assumes a level surface. The condensed mercury flows by means of the pipe *E* to the compartment *G*, and is evenly distributed to compartments *H* and *K* by means of the pipes *R*. The surface of the mercury for feeding purposes contained in the compartments *G*, *H*, and *K* also assumes level surfaces in each compartment, and it will be obvious that the static heads H_1, H_2, and H_3 for feeding the tubes *S* are all maintained equal. (British patent no. 240,237 applied for June 26, 1924, *Illustrated Official Gazette*, Sept. 28, 1925. Compare *The Engineer*, vol. 140, no. 3646, Nov. 13, 1925, p. 536, 1 fig., *d*)

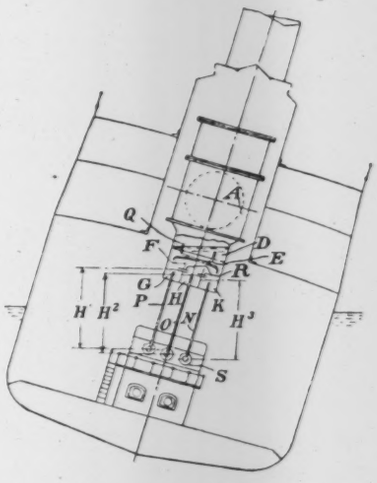


FIG. 4 MARINE-TYPE MERCURY-VAPOR GENERATOR

Steam Service at 100 Atmospheres Pressure in Vienna

DATA of a high-pressure steam plant installed in the Vienna Locomotive Works, Floridsdorf, according to the designs of Professor Löffler, in order to test his new method of generating high-pressure steam.

In this method the water is not evaporated in water tubes but in a boiler drum lying outside of the furnace, for instance, near the prime mover, so that the latter automatically regulates the evaporation. Evaporation is achieved only by admitting superheated steam to the water of the evaporator, and any required increase of pressure may be obtained by varying the heat content of the superheated steam. Only the superheater consisting of coils of tubes of small diameter lies within range of the furnace. It offers the greatest safety even at the maximum pressure. The steam is forced through these coils into the evaporator by means of a special circulating pump. In the tubes of the superheater only steam free from hindrances due to presence of water and scale circulates. The feedwater is pumped into the distant evaporator and scale, if formed, acts only as a heat protector since no heat flows from outside to the inside, and only the superheat of the steam is distributed in the feedwater. Supplementary steam is required to start up the cold plant for the first time. This starting steam may be taken either from another plant or may be generated by an auxiliary low-pressure boiler which would be shut down after the starting of the main boiler. An increase of pressure from 12 atmos. initially to 100 atmos. requires approximately 1 hr.

It is claimed that, especially in plants where the high-pressure steam is employed both for power and heating purposes, a very great saving in fuel may be achieved as compared with the present low-pressure plants by using pressures of 100 atmos. and over, the

saving amounting to 50 per cent or more. It is claimed that such pressures can be applied to locomotives, and at the present moment new steam-engine parts are being tested in the locomotive works at Floridsdorf under service conditions. The question of materials presents no difficulties, and open-hearth steel is used exclusively in the test plant described. (*Engineering Progress*, vol. 6, no. 10, October, 1925, pp. 313–314, 1 fig., *d*)

RAILROAD ENGINEERING (See also Engineering Materials: New French Rail Specification)

Replacement of Oil by Powdered Lignite on Locomotives

THE International Great Northern Railroad is equipping one of its locomotives in its shops at Palestine, Tex., for burning pulverized lignite in place of crude oil. This is at present only an experiment, however. It is stated that the Comal Power Co. and a number of other large fuel consumers in Texas are arranging to substitute pulverized lignite for oil. (*Daily Metal Trade*, vol. 15, no. 233, Nov. 24, 1925, front page, *g*)

STEAM ENGINEERING

Graphical Design of Steam Turbines

THE computation of multi-stage turbines such as used with high-pressure and high-temperature steam is so time-consuming that there have been many attempts to provide graphical methods of design. The present work is based on a publication by Henne, Forschungsheft No. 260, and the author attempts to apply to turbine design the comparatively newly developed method of applied mathematics, namely, nomography.

The author applies his graphical method in this instance to the design of reaction-type turbines, although it may be applied to other types as well.

The efficiency on the periphery of the wheel according to Banki may be expressed, as follows:

$$\eta_u = \frac{2k_1 \cos \alpha_1 - k_1^2}{2k_1 \cos \alpha_1 - k_1^2 + \xi} \quad \ldots\ldots [1]$$

where $k_1 = u/c_1$ and is the ratio of velocities. The notation of Fig. 5 is used in this equation, and the assumption is made that the exit velocity of one stage is employed without loss in the next stage, so that $c_0 = c_2$; further, it is assumed that the degree of reaction, i.e., the ratio of the adiabatic drop from stage to stage converted in one wheel to the total adiabatic drop is $\rho = 0.5$, and that the coefficients of loss for the guide wheel and rotor wheel are equal to each other, or $\xi = \xi_1 = \xi_2$. From Equation [1] is derived the diagram of Fig. 6, on which is also plotted a numerical example which shows the interconnection of the various magnitudes. The maximum value of the efficiency for a given entrance angle α_1 gives the tangent on the sliding curve from which the value of k_1 (see above) corresponding to that of maximum efficiency $\eta_{u\max.}$ is derived. For the Parsons coefficient K an expression is obtained which is given in the original article. This is, however, not developed further. The author next takes up the subject of axial steam velocity c_a, which is used to compute the length of blades with due consideration to the factor of blade contraction. With an axial velocity ratio $k_a = \frac{u}{c_a}$ this ratio can be computed from the well-known equation

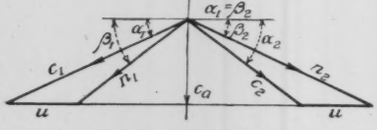


FIG. 5 NOTATION OF MAGNITUDES DEALT WITH IN TURBINE DESIGN BY THE PRESENT METHOD

$$k_1 = k_a \sin \alpha_1 \quad \ldots\ldots [2]$$

The computation of the exit velocity c_2 from the rotor blade is made by using the velocity ratio $k_2 = \frac{u}{c_2}$ and equations

$$c_2^2 = c_1^2 + u^2 - 2\, u\, c_1 \cos \alpha_1$$

$$\left(\frac{k_1}{k_2}\right)^2 = 1 - (2\, k_1 \cos \alpha_1 - k_1^2) \quad \ldots\ldots [3]$$

The exit angle α_2 is then obtained in a simple manner from the equation

$$\sin \alpha_2 = \frac{k_2}{k_a} \quad \ldots\ldots [4]$$

which, however, has not been plotted on the diagram.

In order to compute the number of stages $\overset{s}{\underset{o}{\Sigma}}$ of a given turbine for a given peripheral velocity u with a given drop per stage Σh_{ad}, the following equation is used:

$$\overset{s}{\underset{o}{\Sigma}} = \frac{K \Sigma h_{ad}}{u^2} \quad \ldots\ldots [5]$$

In Equations [1] to [5] are contained all the values which one may need for computing of turbines in groups having the same lengths of blades and the same angles, such as angle of entrance

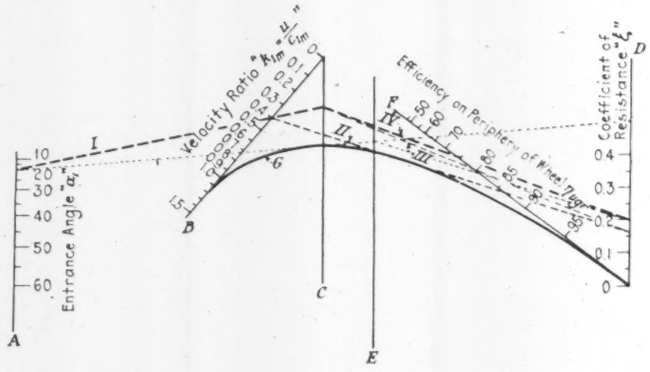


FIG. 6 NOMOGRAM FOR COMPUTING EFFICIENCY OF TURBINE ON THE WHEEL PERIPHERY

α_1, velocity ratio k_1, ratio of axial velocities k_a, velocity ratio k_2, angle of exit α_2, Parsons coefficient K, efficiency at the periphery of the wheel η_u, number of stages $\overset{s}{\underset{o}{\Sigma}}$, drop per groups Σh_{ad}, and a peripheral velocity u. Fig. 7 shows how the values computed from Equations [1] to [5] are combined in a process of calculation, while Fig. 8 gives a numerical example thereof.

Fig. 6 is to be used in the following manner. It has reference to the Banki Equation [1] given in the text and deals with the following example: Angle of entrance $\alpha_1 = 20$ deg.; velocity ratio $k_1 = 0.4$; coefficient of resistance $\xi = 0.2$, from the diagram. Intersection of the straight line IV with the line of efficiencies gives $\eta_u = 75$ per cent. The diagram is to be handled as follows: Connect ruler A with B through line I; lay a tangent (II) from the value on B to the sliding curve G; connect intersections of (I, C) and (II, D) through line III; then connect point (III, E) with the value of ξ on D through line IV; the point (IV, F) will give then the value of the maximum efficiency η_u.

Fig. 8 is to be used in the following manner. Connect the value of α_1 on A with the value of k_1 on B through line I; lay from k_1 a tangent II to the sliding curve G_1 intersecting D then tangent III from k_1 to curve G_2 likewise intersecting D. Connect point (III, D) with point (I, C) by line IV. A connection between point (IV, E) and ξ on D gives line V. Now connect point (V, F) with point (II, D) by line VI. The point of intersection (VI, H) on H gives the value of K. Now project point (V, F) through P through VII on to D. The line VIII connecting point (VII, D) with (IV, E) gives in its point of intersection (VIII, J) with J the value of η_u. Now project point (IV, E) through point P_1 on L, through line IX. The line X connecting the points (IX, L) and (III, D) gives in the point of intersection (X, M) on line M the value of k_2. Connect the value of u on O with the value of Σh_{ad} on Q by line XII; the point (XII, J) connected by XIII with the previously determined value of K on H gives by the intersection (XIII, R) the value of $\overset{s}{\underset{o}{\Sigma}}$ on

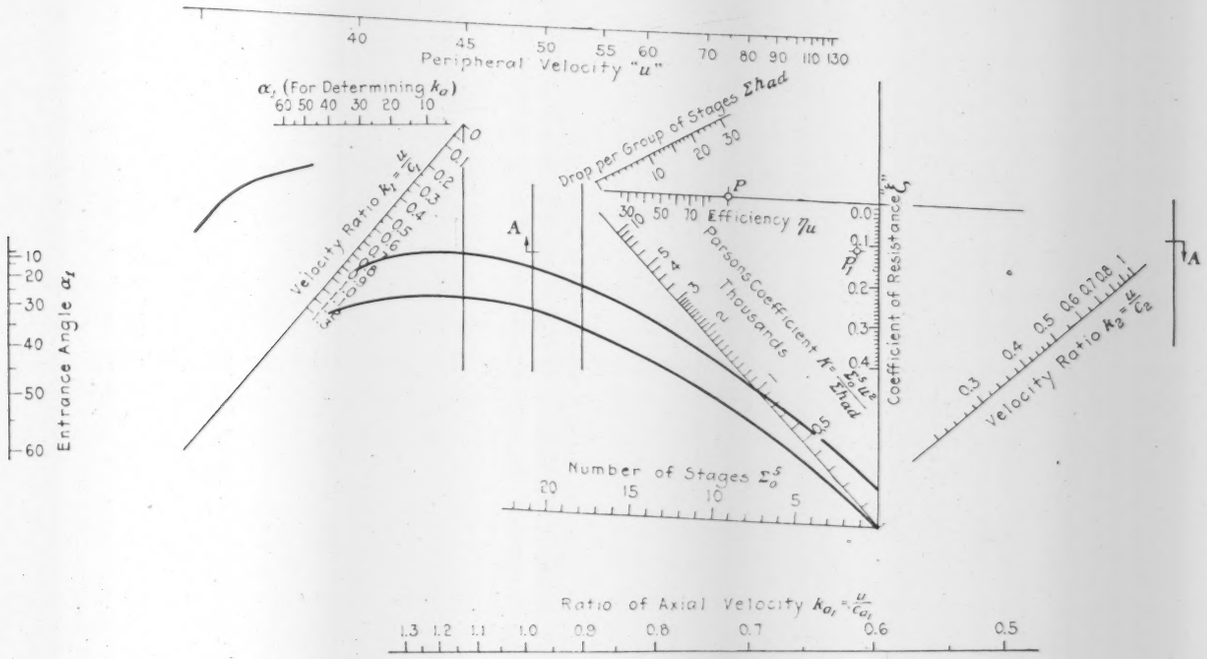

Peripheral Velocity "u"
Drop per Group of Stages Σhad
Efficiency ηu
Coefficient of Resistance ζ
Parsons Coefficient K = Σs u² / Σhad
Thousands
Number of Stages Σo s
Entrance Angle α1
Velocity Ratio k1 = u/c1
Velocity Ratio k2 = u/c2
Ratio of Axial Velocity ka1 = u/ca1

FIG. 7 NOMOGRAM FOR COMPUTING VARIOUS ELEMENTS OF A REACTION TYPE STEAM TURBINE

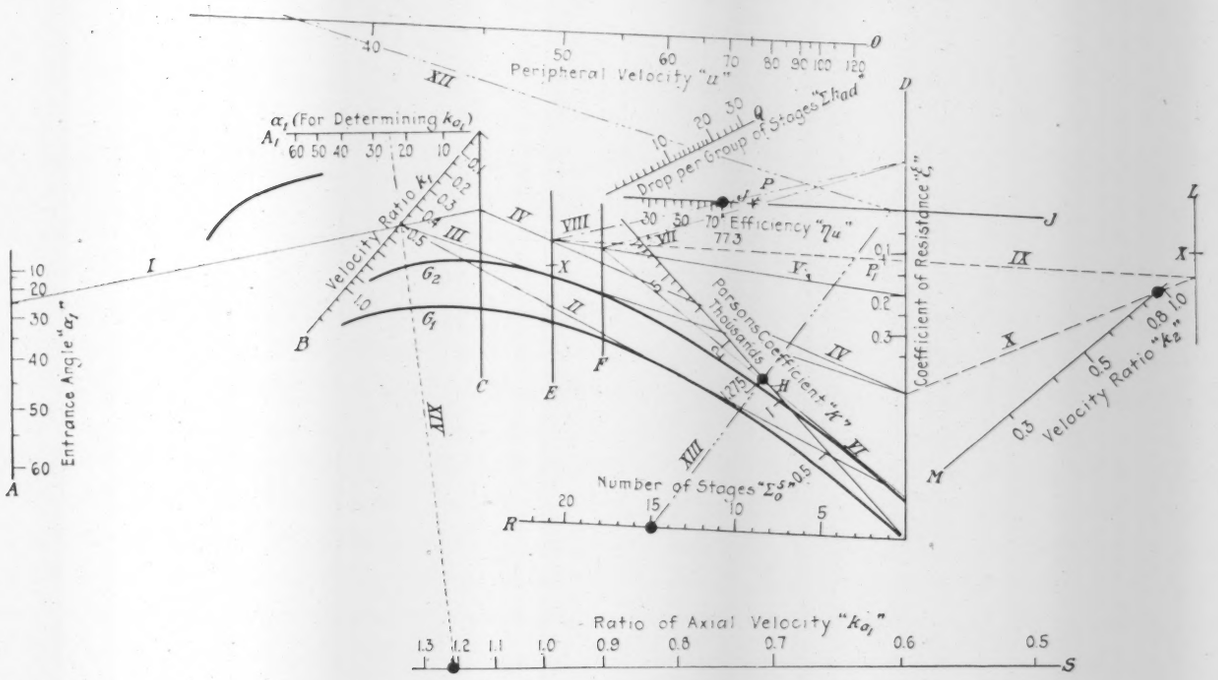


FIG. 8 APPLICATION OF NOMOGRAM SHOWN IN FIG. 7

R, while the value of α_1 on A_1 connected with k_1 by XIV gives in point (XIV, S) on S the value of k_{a1}. (A. Oppitz, Kiel, in *Archiv für Wärmewirtschaft*, vol. 6, no. 10, Oct., 1925, pp. 271–273, 4 figs., *pA*)

TESTING AND MEASUREMENTS

A New Repeated-Torsion Tester

IN a high-speed repeated-torsion tester of constant stress-range type designed by the author, one end of the test piece is to be chucked to the armature of an oscillating motor and the other end to a torsion bar. The torsion bar is used to measure repeated torque by the method of lamp and scale. The construction of the oscillating motor is the same as that of an ordinary d.c. motor, but alternating current or pulsating current of any frequency is supplied to the armature while direct current is supplied to the field coils, as a result of which the armature exerts alternating or pulsating torque on the test piece.

The so-called rapid method proposed by Gough can also be used simply and accurately with this machine (but the author could not find such a fatigue limit as found by Gough).

On carrying out the endurance test, it is advisable to use the resonance phenomena of torsional vibration, because in the vicinity of that frequency the armature current decreases and the wave form of repeated torque becomes more regular.

By adding some simple attachments to this machine, ordinary simple torsion tests can also be carried out.

The test pieces to suit this machine can be made simply and accurately by means of a milling machine, giving rotation and axial feed to the test pieces. (Bunzaburo Kuraishi in Japanese, with brief English abstract in *Journal of the Society of Mechanical Engineers*, vol. 28, no. 102, Oct., 1925, pp. 797–819, illustrated, *dg*)

Viscometry in the Sibley School of Mechanical Engineering

A GENERAL article dealing with viscometry in a comprehensive manner from a practical point of view, together with a discussion of some theoretical problems. Only a few parts of this interesting article can be abstracted here. The author describes several of the standard viscometers, including the Michell, with their advantages and limitations, and also a simple type for the determination of viscosity at room temperature. This instrument is made in the form of a glass pipette and has in the middle a bulb of about 10 to 25 cc. capacity and a tube at each end about 10 to 15 cm. (4 to 6 in.) long. One of the end tubes has an internal diameter of about 1 mm. and the other of about 3 to 6 mm. (These dimensions are suggested merely to illustrate the scheme of design.) To operate, the pipette is sucked full of oil sample, the oil being drawn up through the larger end tube. Then the pipette is inverted, and the measurement is the time required for the bulb to empty by gravity through the smaller end tube. By proper choice of constants for the bulb and tube the kinetic-energy correction should be kept below 5 per cent even for light oils, and the ratio of viscosity to density of the oil could be made to be efflux time in seconds divided by some desired set even number, such as 100, 200, or 1000. A set of two or three such viscosity pipettes would answer a large number of commercial requirements—for example, loss of viscosity by dilution in automobile engines. The weakness of this apparatus is that it cannot be used for oil at a temperature much different from room temperature.

In the author's work a number of defects in design or operation of the Engler viscometer were found, and he describes how they were corrected. Among other things, the discharge tube of the Engler viscometer was changed, with the result that the approach correction became relatively small.

The author proceeds then to a review of the mathematical theory of the flow viscometer. This part, while of interest, is not suitable for abstracting. The author also describes a viscometer which he designed himself and which he refers to as the Cornell viscometer. (Prof. G. D. Upton, Mem. A.S.M.E., in *Bulletin of the Engineering Experiment Station, College of Engineering, Cornell University*, no. 5, Oct. 1, 1925, pp. 1–22, 2 figs., *pt.A*)

THERMODYNAMICS (See also Internal-Combustion Engineering: A Thermodynamic Analysis of Gas-Engine Tests)

The Present State of Research Dealing with the Physical Properties of Water Vapor

THE author reviews the recent work of German, Swiss, and American investigators, in particular that carried out at the Bureau of Standards, Harvard University, and Massachusetts Institute of Technology. He comes to the conclusion that the general agreement of results obtained by German investigators and experimental verification of some of their figures make it permissible to use these data safely for pressures up to 60 atmos. notwithstanding the fact that c_p has been measured only up to 30 atmos., and r and u' only up to 20 atmos. There is little doubt that these figures will be confirmed by the investigation now under way by Jakob on r and by the Munich Laboratory on c_p at high temperatures. (Chas. Roszak in *Mémoires de la Société de Ingénieurs Civils de France*, Series 8, vol. 78, nos. 7–8, July-Aug., 1925, pp. 570–583, *c*)

Dissipation of Heat by Bare Iron Pipe

THE author begins by giving a history of the subject and mentions the following investigations: Professor Rietchel's, published in Germany in 1913 but actually carried out about 1890; Professor Barker's, published in his Theory and Practice of Heating and Ventilation, London, 1912; L. B. McMillan's (Mem. A.S.M.E.), based on tests made at the University of Wisconsin and published in Transactions of The American Society of Mechanical Engineers, 1915, vol. 37, pp. 941. These tests were made with pipe temperatures ranging from 175 to 575 deg. fahr. and do not give any indications for temperature differences that are smaller than 100 deg. fahr.

The next investigation mentioned is that carried out by F. Wamsler in Munich in two different ways. This gives coefficients of heat radiation from various substances, and an attempt is made to establish a law according to which for a range of temperatures from 0 deg. to 350 deg. these coefficients vary as the fourth power of the absolute temperatures. Dr. Nusselt in the 1920 edition of the German Hütte gives an improved formula for determining the portion of heat dissipated by contact of the pipe with the surrounding air. Next, about 1921 or 1922, R. H. Heilman (Mem. A.S.M.E.) made an experimental determination of the dissipation of heat by 1-, 3-, and 10-in. pipes at the Mellon Institute in Pittsburgh. The results of this investigation were published in the Transactions of The American Society of Mechanical Engineers, vol. 44, pp. 299–310.

The author believes that the formulas of Nusselt and Wamsler give better results than the Heilman curves, and comes to the conclusion that for small temperature differences the curve representing k, the heat dissipated by contact with the air, should be convex upward, and that for large temperature differences,

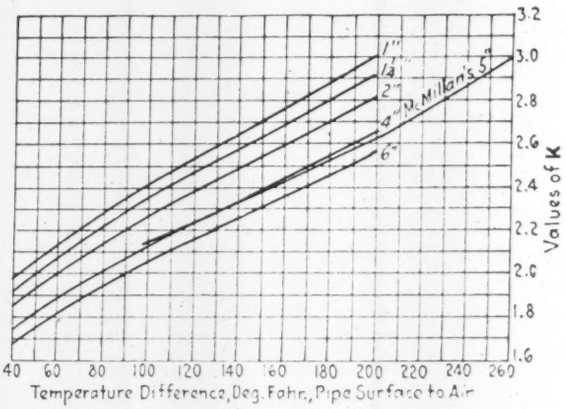


FIG. 9 PROPOSED COEFFICIENT OF HEAT LOSS FROM BARE IRON PIPES BASED ON RESULTS OF WAMSLER'S, NUSSELT'S, MCMILLAN'S, HEILMAN'S, AND THE AUTHOR'S INVESTIGATIONS

when the larger part of the heat is dissipated by radiation, the curve should be concave upward. He derives, therefore, the following formula:

$$k_2 = 0.44\ (t_1 - t_2)^{0.25}\ d^{-0.2}$$

where k_2 = heat dissipated by air conduction and air convection in B.t.u. per. sq. ft. per hr. per. deg. fahr.; t_1 = temperature of iron pipe surface in deg. fahr.; t_2 = average temperature of air surrounding the pipe in deg. fahr.; and d = outside diameter of pipe in inches.

The results given by this formula agree with the Wamsler values for the 1 ¼-in. pipe, with the McMillan values for the 5-in. pipe, and with the Heilman values at a temperature difference of 200 deg. fahr., and furthermore they retain the form of curve found by Wamsler.

It appears, therefore, that the values of the heat-dissipation coefficient for bare iron pipe shown in Fig. 7 represent quite accurately the collective results of all tests available at the present time, particularly when the temperature difference is 100 deg. fahr. or greater.

It is evident that the value of the heat-dissipation coefficient must be zero when the temperature difference is zero, and therefore that the curves shown in Fig. 9, when extended, pass through the origin of coördinates.

Additional tests were carried out at the University of Texas. These test results showed in some instances no difference in temperature when there must have been one, which the author tries to explain away. The three sets of k values obtained did not coincide, but the extreme variation from the mean was found to be only about 3 per cent, and the values are probably as accurate as should be expected under the conditions of the test, which were anything but perfect. (F. E. Giesecke, Professor of Architectural Engineering, University of Texas, in *The Heating and Ventilating Magazine*, vol. 22, no. 11, Nov., 1925, pp. 54–59, 13 figs., *he*)

Graphical Representation of the Specific Heat of Steam at High Pressures

THE author, himself a leading writer on thermodynamics in Germany, points out that with the modern tendency toward commercial employment of high steam pressures, a knowledge of the thermodynamic properties—especially specific heat—of steam at the higher ranges becomes of great importance. Knoblauch determined experimentally the specific heat of steam up to a pressure of 30 atmos. and a temperature of 350 deg. cent. (662 deg. fahr.). He then by extrapolation carried the results of his work up to a pressure of 60 atmos. and worked out tables, the correctness of which was substantially confirmed by later calculations. It was also necessary to express the experimental results in the form of an equation. To do this with the experimental data as a basis, involved the use of a $c_p t$ diagram containing isobars of specific heat curved like hyperbolas. These latter were found to be expressed with quite satisfactory precision by an equation of the form

$$c_p = f(T) + \frac{C}{T - \varphi(p)} \quad \ldots\ldots\ldots\ldots\ldots\ldots [I]$$

where $f(T)$ is a function of temperature, $\varphi(p)$ is a function of pressure, and C is a constant. By various methods, among others the method of least squares, the constant and the above functions were determined and an expression for c_p was derived that was much simpler than the previous equations of R. Plank and G. Eichelberg. Moreover the new equation was brought into agreement with the most recent experimental results, and made it possible, by a double integration of the Clausius equation

$$\left(\frac{\partial c_p}{\partial p}\right)_T = -AT\left(\frac{\partial^2 v}{\partial T^2}\right)_p$$

to obtain an expression for the specific volume v. Since we have to deal here with the solution of a partial differential equation, two simultaneously indeterminate pressure functions are obtained, the first of which follows from the condition that for $T = \infty$ the quotient $\left(\frac{\partial v}{\partial T}\right)_p = \frac{R}{P}$. R being the gas constant. The second function, denoted by $\Psi(p)$, is derived from the value for the specific volume of dry saturated steam at 180 deg. cent. (356 deg. fahr.) determined experimentally. In this way we arrive at the equation which may be designated as the equation of state:

$$v = \frac{RT}{p} - \frac{C\varphi'(p)}{A[\varphi(p)]^2}\left[T \log_e \frac{T}{T - \varphi(p)} - \varphi(p)\right] + \Psi(p) \ldots [II]$$

Using equations [I] and [II], Knoblauch, who had particularly in mind the construction of a Mollier diagram that would answer all requirements, proceeded to the calculation of the entropy s and heat content i. As regards the first of these two, he used the thermodynamic relation $ds = \frac{c_p dT}{T} - A\left(\frac{\partial v}{\partial T}\right)_p d_p$, and from this derived the expression

$$s = s_e + \int \frac{f(T)}{T} dT - \frac{C}{\varphi(p)} \log_e \frac{T}{T - \varphi(p)} - AR \log_e p \ldots [III]$$

The constant of integration s_e which occurs in [III] can be determined provided one knows for a given temperature the saturation pressure of the steam and the corresponding heat of evaporation r and entropy s' of the liquid, and provided one takes into consideration that $(s'' - s')T_s = r$, where s'' is the value of s with dry saturated steam. The science of thermodynamics provides the following expression for determining the heat content:

$$di = c_p dT - A\left[T\left(\frac{\partial v}{\partial T}\right)_p - v\right] d_p$$

From this equation, by substituting the values given above for v and c_p, Knoblauch found the following equation:

$$i = i_e + \int f(T)dT + C \log_e [T - \varphi(p)] + A \int \Psi(p) d_p \ldots [IV]$$

The constant i_e may be determined from the formula $i'' - i' = r$, where i'' is the heat content of dry steam and i' the heat content of the liquid. The latter as well as the heat of evaporation r can be considered as having been within certain limits determined by test. The value of i'' found by test may be compared with that determined from Equation [IV], and thus i_e may be found.

The method for calculating s_e and i_e described above has been employed not for one but—for the sake of greater precision—for a good many points on the saturation line, in so far as it was possible to determine them by test. There is therefore scarcely any doubt that the greatest care was used in the derivation of these values, and this impression is strengthened further when one considers the control calculations carried out by Knoblauch and his collaborators.

The following check calculation deserves particular attention. First the heat of evaporation was determined from the expression $r = (s'' - s')T_s$. This was done by combining the value of s'' calculated from Equation [III] with the values of T_s and s'' obtained experimentally. Next r was determined from the Clausius-Clapeyron equation $r = AT\frac{dp_s}{dT}(v'' - v')$, using the tables of the State Physico-Technical Bureau as well as data obtained by various investigators for v'', v' and $\frac{dp_s}{dT}$. Finally, the results of the two processes of calculation presented above were compared with the values of the heats of evaporation experimentally determined by Henning and were found to be in most excellent agreement with them. Nevertheless too much should not be expected from the Knoblauch diagrams, considering that they were obtained by extrapolation. Within certain limits there is always present the possibility of error due to the use of such diagrams or to the uncertainty concerning the heats of evaporation and the values of specific volume of saturated steam which hitherto have been experimentally determined only to a limited extent, and as would appear from what has been said above, these values dominate in the method of calculation described above. In particular, r is of the utmost importance for locating the upper limit curve of the IS-diagram, which, in its turn, as has been rightly emphasized by A. Bantlin, forms the backbone of the whole structure. It is at this curve that all the lines affecting the region of saturation end and the lines for superheated steam begin. All of these lines will be displaced if even a slight error is permitted in the location of the limit curve, and yet it can be hardly questioned that under certain conditions a change in the latter may have to be made, considering that the views of such prominent investigators as Schüle, Eichelberg, Knoblauch, and others were by no means in agreement but a short time ago as to the course of r. However, the differences between these investigators have recently been cleared up to a certain extent, though complete certainty will be obtained only when the heats of evaporation and specific volumes are determined experimentally with a greater degree of precision than is now possible. Nevertheless there is no reason to doubt that with the knowledge we already have, an attempt to obtain the necessary information by extrapolation is fully justified. For thermodynamic calculations dealing with pressures which do not exceed 30 atmospheres, the IS-chart of Bantlin is the most convenient, because of its large scale and of the fact that it has v-curves plotted on it. Stodola agrees with the above-expressed view considering the feasibility of using extrapolations. He has gone even farther than Knoblauch and has plotted an IS-diagram which covers the whole region up to the critical pressure. He did not use for this purpose the Eichelberg equations, which he had employed previously, but instead adopted as a basis the more modern observations dealing with pressures up to 30 atmos., and from this he derived $\frac{\partial C_p}{\partial p}$ curves and extrapolated them, obtaining the c_p-values by graphic integration. The result was that at high pressures the values were found to be considerably different from those determined by Knoblauch. It is impossible to determine theoretically which of the two sets of values is more correct. It may be pointed out, however, that the equation given by Knoblauch for the specific heat yields on extrapolation satisfactory values both above and below the ranges of actual observation.

In accordance with the kinetic theory of gases molecular complexes form upon approach to the point of saturation (see Fig. 10). Hence the isobars for $p = 0$ must go down to the saturation line,

while the other c_p-curves must show a minimum in the Tc_p diagram. On the other hand, it is necessary that for the critical point $c_p = \infty$, as the following equation holds good:

$$c_p = \left(\frac{\partial u}{\partial t}\right)_p + Ap\left(\frac{\partial v}{\partial t}\right)_p = \frac{\left(\frac{\partial u}{\partial v}\right)_p + Ap}{\left(\frac{\partial t}{\partial v}\right)_p}$$

where u represents the variation of internal energy, and the denominator at 374 deg. cent. and 225.05 atmos. is equal to zero since in the pressure-volume diagram the isothermal at that point shows a change of direction with the horizontal tangent.

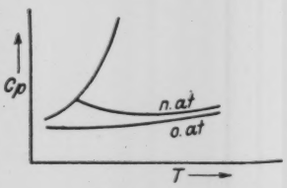


Fig. 10

The Knoblauch equation satisfies both of these requirements, which is strongly in its favor. On the other hand, the results arrived at by Stodola show no indication of being incorrect, and are fully consistent with each other. A favorable indication may be also seen in the most recent investigations concerning the heat of evaporation carried out by Blomquist and extending up to a pressure of 100 atmos. These observations were not available when the Knoblauch diagrams were plotted. Stodola by using the Clapeyron equation determined from them $r = AT\frac{dp_s}{dT}(v'' - v')$ in which the quantity in the parenthesis represents the difference between the specific volume of vapor and liquid, the volume v'' referring to the dry saturated state. For the purpose of computation of the extremely important relation between pressure and temperature at the limit curve the data of Holborn, Henning, and Baumann were used. The heat content i and the entropy were determined graphically from the c_p values, while in order to develop the equation of state resort was again had to the Clausius equation $\left(\frac{\partial v^2}{\partial T^2}\right)_p = -\left(\frac{\partial c_p}{\partial p}\right)_T \frac{1}{AT}$, in which was substituted the value of $\left(\frac{\partial c_p}{\partial p}\right)_T$ found in the manner indicated above.

The volume curves little resemble either the curves of Stodola or those of Knoblauch, and as an indication of the rapidity of progress of the theoretical investigation it may be pointed out that the equations developed in 1920 by Eichelberg have already been superseded, although in their time they satisfied all requirements and were in agreement with all the known facts. It is by no means unlikely but quite natural in view of the use of extrapolation, that the figures of Knoblauch and Stodola, where they are dealing with pressures in excess of 30 atmos., will suffer a similar fate.

R. Mollier, who was the first to plot an *IS*-diagram, has also recently devoted some attention to the consideration of the value of the most recent investigations dealing with specific heat. In his diagram published in 1904 he made the assumption that the specific heat of steam is constant. When it was found that such an assumption is not correct, Mollier worked out other diagrams of steam based on the equation of state of Callendar, which, as we know, is expressed by $v = \frac{RT}{p} f(t)$, where $t = T - 273$. This equation held good for a long time, but even it had to be abandoned when dealing with high pressures, and Mollier devoted his attention next to the problem of finding an equation of state where the powers of the pressures would form a progressive series and the coefficients of the series, functions of the temperatures. In the course of tests having this aim in view he came to the very remarkable conclusion that in the region below 30 deg. atmos. pressure, where the properties of steam are fully known from actual experimental work, the equation

$$v - \frac{RT}{p} - \frac{\alpha^2}{T^{10/3}} - b^2\frac{p^2}{T^{12}}$$

represents the results of the latest observations with the utmost precision. The idea that the same equation may hold good for other regions of pressure is unusually attractive because of its great simplicity. Unfortunately, it is hardly likely to be so, as this equation when extrapolated to higher pressures leads to obvious inconsistencies. For example, if we calculate the value of $\varphi = s - \frac{i}{T}$ after substituting the values of p and T from the steam-pressure curve, we ought to obtain the same result that has been obtained for the liquid by the tests by Dieterici, i.e., $\varphi = \varphi''$. Actually, however, this is not the case above 30 atmos., and Mollier had to proceed to the development of a new equation of state,

$$\frac{pv}{T} = 47.1 - 0.02\frac{p}{(T/100)^{13/4}} - \frac{1.9}{10^6}\frac{p^3}{(T/100)^{15}}$$

This satisfied the above requirement, which was, however, not sufficient to permit the unquestioned use of the equation, and it was decided to test it by comparison with better-known substances.

This process has a certain justification in the light of what the author calls the "principle of coinciding states." He formulates this principle as follows: If we express the pressure in fractions of the critical pressure, the volume in fractions of the critical volume, and the temperature in fractions of critical temperature, the equations of state for all substances will have the same form. This theory has rendered good service in many instances, yet careful investigation would indicate that not in frequentlyit is only approximately correct and requires further elaboration before it can be generally accepted. The application of this principle seems to become questionable when dealing with abnormal substances, which water is, however considered. Nevertheless Mollier decided to adopt the process of comparison. The magnitude $\frac{pv''}{RT}$ has been plotted on the limit curve as a function of the "reduced" temperature, i.e., the quotient of the temperature and its critical value, and the results following from the equation of state have been compared with those obtained from an investigation of other materials, particular attention being paid also to the abnormal ammonia. Mollier further determined the fraction $\frac{pv}{R}$ as a function of the "reduced" pressure and compared the results with isopentane. This led him to accept as likely the correctness of his equation. One cannot deny a considerable degree of reliability to his tables and diagrams, of which the *IS*-diagram comprises the whole region up to the critical pressure. His diagrams also contain the v-curves and give a very clear presentation of the subject, especially because of his use of color in their preparation. (Herr Schmolke, Berlin, in *Die Wärme*, vol. 48, no. 34, Aug. 21, 1925, pp. 427–429, 1 fig., *t*)

TRANSPORTATION

Moving Sidewalks in Paris

Under the auspices of the Government Inventions Bureau, tests of moving sidewalks are being carried out at Bellevue, near Paris. A preliminary investigation of the subject led to the decision to employ only moving sidewalks of the endless-belt type, and two systems are being actually tried. At each station there is an accelerator arrangement which progressively increases the speed of the passenger from that of walking to 12 km. (7.8 miles) per hr. and from the movable platform going at this speed the passenger steps off on to the sidewalk proper which has a speed of 15 km. (9.3 miles). The passenger does not have to hurry as he can step off on to the moving sidewalk within 9 sec. In getting off the procedure is reversed. It is estimated that either of the systems under trial can transport from 70,000 to 72,000 persons per hr. at a speed of 15 km. (9.3 miles) per hr., while the capacity of the Paris subway is only 12,000 per hr. (Jacques Boyer in *La Nature*, no. 2692, Nov. 7, 1925, pp. 289–291, 4 figs., *d*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Engineering and Industrial Standardization

The Standard Ton of Refrigeration

THE special standards committee on Standard Tonnage Basis for Refrigeration submitted a report to the A.S.M.E. last month which was in the form of an extension of its May, 1921, report. The personnel of this Committee is as follows: F. E. Matthews, Chairman, H. Torrance, Jr., Secretary, C. W. Berry, P. Neff, J. E. Starr and G. T. Voorhees, and it will be recalled that its first report appeared in the January, 1921, issue of MECHANICAL ENGINEERING.

The proposed standard in its present amended form reads as follows:

(1) A standard ton of refrigeration is 288,000 B.t.u.

(2) The standard commercial ton of refrigeration is at the rate of 200 B.t.u. per minute.

(3) The standard rating of a refrigerating machine[1] using liquefiable vapor is the number of standard commercial tons of refrigeration it performs under adopted refrigerant pressures.[2]

(*a*) The inlet pressure is that which corresponds to a saturation temperature of 5 deg. fahr. (—15 deg. cent.).[1]

(*b*) The outlet pressure is that which corresponds to a saturation temperature of 86 deg. fahr. (30 deg. cent.).[1]

(*c*) Nothing but liquid shall enter the expansion valve, and nothing but vapor shall enter the refrigerating machine.

(*d*) There shall be 9 deg. fahr. (5 deg. cent.) sub-cooling of the liquid entering the expansion valve and 9 deg. fahr. (5 deg. cent.) superheating of the vapor entering the refrigerating machine, the points at which the sub-cooling and the superheating are determined to be within 10 feet of the expansion valve and refrigerating machine, respectively.

Criticisms and comments on this report are solicited by the A.S.M.E. Standardization Committee and should be mailed to C. B. LePage, Secretary to the Committee, 29 West 39th Street, New York, N. Y.

Transmission Chains and Sprockets

AT THE present time the reorganization of the joint committee of the S.A.E., the A.G.M.A., and the A.S.M.E. on the standardization of roller chains and sprockets into a Sectional Committee under the procedure of the A.E.S.C. is in progress. The reports of the joint committee were published in the September, 1921, and August, 1923, issues of MECHANICAL ENGINEERING, and also as data sheets of the Society of Automotive Engineers.

The first work of the Sectional Committee will therefore be a complete review of the standards developed by the former joint committee. It will turn its attention then to the development of national standards for chains and sprockets of sizes and types not covered by the earlier reports.

Joint sponsorship for this project under the auspices of the American Engineering Standards Committee has been accepted by the Society of Automotive Engineers, the American Gear Manufacturers' Association, and The American Society of Mechanical Engineers.

Japanese Number Systems

IN THE October, 1925 issue, page 858, there appeared a report of the American Engineering Standards Committee regarding the adoption of two preferred-number series by the Japanese, one similar to the European system called "standard diameters," and one based on geometric series, like the German and French "Numbers for Standardization."

Late advices received from the Japanese state that the "standard dimensions" were chosen to correct the tendency toward increasing the number of different dimensions entering into design, slightly different sizes being selected for purposes for which no differentiation is really needed, so that gradually a meaningless and confusing diversity of sizes grows up involving the use of an unnecessarily large number of drills, taps, dies, jigs, fixtures, and other tools entering into manufacture. The Japanese have extended the use of these numbers to other dimensions than diameters (to which the Europeans have restricted them), but it is thought that their use will be mainly for individual objects, where a change of 1 or 2 mm. in a size to bring it to one of the "standard dimensions" will not make any practical difference.

The preferred numbers of the geometric type are intended more for series of speeds, kilowatt ratings, etc., and it is felt that they afford a more rational attack on the problem of *series of sizes* than do the more arbitrarily selected numbers of the other series.

Jottings Made at the A.S.M.E. Annual Meeting

Tee Slots. The Sub-Committee on Tee Slots, of which Erik Oberg is Chairman, held a meeting on December 1 and approved a report for submission to the Central Committee on the Standardization of Small Tools and Machine Tool Elements and to the Sponsors. This report will be available shortly in the form of printer's galley proofs.

Identification of Piping Systems. An Editing Committee made up of the officers and certain other members of the Sectional Committee has recently been appointed by Chairman A. S. Hebble to combine the reports of the three sub-committees into one complete report. This Committee has been asked to endeavor at the same time to so modify these reports that a Code on Identification of Piping Systems which will be acceptable to all interests may be presented to the Sponsor Bodies (N.S.C. and A.S.M.E.) and by them to the A.E.S.C.

Plain Limit Gages for General Engineering Work. It was reported at the December meeting of the A.S.M.E. Standardization Committee that the report on Tolerances, Allowances, and Gages for Metal Fits had been voted on a second time by the A.E.S.C. and that a favorable vote had just been completed. This report therefore is available now in pamphlet form. Address A.S.M.E. Publication-Sales Department; price fifty cents.

Cast-Iron Flanges and Flanged Fittings. Sub-Committee No. 1 in charge of the revision of the 1914 Standard for 125 and 250 lb. per sq. in. Steam Pressure Standard Cast-Iron Flanges held a successful meeting on December 2. As a result, revised drafts of these two standards were approved for submission to the Sectional Committee and a new series of low-pressure cast-iron flanges for pressures of 50 lb. per sq. in. and under was both discussed and approved.

These standards will be available in proof form for criticism and comment at the time they are submitted to the Sectional Committee.

Steel Flanges and Flanged Fittings. A three-day session was necessary to enable Sub-Committee No. 3 to complete the revision of its report on standard steel flanges designed to withstand steam pressures of 250, 400, 600 and 900 lb. per sq. in. and a temperature of 750 deg. fahr. This report now goes to the entire membership of the Sectional Committee for study prior to a meeting of that Committee at which it will be presented both for review and for discussion.

At a subsequent meeting of Sub-Committee No. 3 it will consider a report of a sub-group on dimensions for a series of 1350 lb. flanges and flanged fittings.

Wrench-Head Bolts and Nuts. The Sectional Committee on Bolt, Nut and Rivet Proportions held a meeting on December 2 for the purpose of discussing the final report of Sub-Committee No. 2 on

[1] A refrigerating machine is the compressor cylinder of the compression refrigerating system, or the absorber, liquor pump, and generator of the absorption refrigerating system.

[2] These pressures are measured outside and within 10 ft. of the refrigerating machine, measured along the inlet and outlet pipes, respectively.

Wrench-Head Bolts and Nuts. This report had been previously distributed to members of the larger committee in page-proof form. After full discussion this report was ordered to letter ballot of the Sectional Committee without modification. Upon approval it will be submitted to the sponsors (S.A.E. and A.S.M.E.) and by them transmitted to the A.E.S.C.

Drawings and Drafting Room Practices. The general conference held under the auspices of the American Engineering Standards Committee was largely attended by accredited representatives and, after full discussion, it was voted to recommend the formation of a Sectional Committee to undertake this project.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St. New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in MECHANICAL ENGINEERING.

Below are given interpretations of the Committee in Cases Nos. 484 (Reopened), 498, 499, 512, 513, and 514 as formulated at the meeting of October 23, 1925, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 484 (Reopened)

Inquiry: Is it permissible to connect a low-water signal or alarm of the whistle type to the water-column or water-gage connections of a boiler?

Reply: It is the opinion of the Committee that Par. P-295 of the Code was intended to permit the connection or attachment of any form of apparatus to the pipes connecting a water column to a boiler (such as high- and low-water alarms) which do not permit the escape of an appreciable amount of steam or water therefrom.

CASE NO. 498

(In the hands of the Committee)

CASE NO. 499

Inquiry: How is the grate area to be calculated when applying the exemption of 15 sq. ft. in Par. P-200 to the drilling of telltale holes in staybolts?

Reply: It is the opinion of the Committee that in applying the exemption in Par. P-200 it was the intent that the term "grate area" as here used should be the horizontal cross-sectional area of the opening at the bottom of the firebox.

CASE NO. 512

(In the hands of the Committee)

CASE NO. 513

Inquiry: Is it not the intent of Par. P-184*a* that the strength of circumferential joints of boilers whose heads are not supported by tubes or through stays shall be at least 50 per cent of that required for either the longitudinal joints of the same structure, or the ligaments between tube holes therein, whichever is the weaker?

Reply: Par. P-180 provides that either the efficiency of the longitudinal joint or the efficiency of the ligaments between tube holes in a shell or drum shall be taken into consideration, whichever is the lesser. It is therefore the opinion of the Committee that in Par. P-184*a* the strength of the circumferential joints shall not be less than 50 per cent of that required for either the longitudinal joints or the ligaments between tube holes in the same structure, whichever is the weaker.

CASE NO. 514

Inquiry: (*a*) Should not the height of the flange for a manhole opening in a dished head as provided for in Par. P-198 correspond to the height for a manhole frame as referred to in Par. P-260 and Fig. P-17 of the Code?

(*b*) Also, should not the height specified in these requirements be the height of the finished gasket surface, and should this not represent the minimum where the manhole is located in the shell of a cylindrical vessel?

Reply: (*a*) The rule in Par. P-198 pertains merely to the forming of a flanged manhole in the material of a dished head and takes no account of the reinforcement of such an opening. Where reinforcement of such a manhole opening in a dished head is required, Par. P-260 will apply.

(*b*) The rule in Par. P-260 pertains to that portion of the flanged section of a manhole frame that may be added to the flat portion of the frame for calculation of its strength in reinforcement of the shell. It is the opinion of the Committee that where a flanged manhole frame as shown in Fig. P-17 of the Code is applied for purposes of reinforcement of the shell, the height of flange considered for reinforcement shall be its minimum height on the axis which is parallel to the axis of the shell.

The Engineer and Civilization

(*Continued from page 5*)

CONCLUSION

To sum up the whole matter, the engineer, either as an individual or as a collective type, is simply a link in the chain of human progress—a chain the links of which, in one form or another, run back into a past removed from our own time by tens of thousands of years, to go to no higher figures. With the trend of human progress as it now is, he seems, moreover, to be a very necessary link. He has taken upon himself the peculiar function of developing and translating into use for the needs of civilization the constructive materials of the earth and the inorganic energies of nature, and in connection with the exercise of such function he has acquired peculiar and weighty duties and responsibilities.

There are naturally the duties of self-development and improvement, both individually and collectively as organizations such as our own. This is the duty so well inculcated by the Scriptural parable of the talents. Likewise there are the duties of friendship and of coöperation for the realization of larger ends, and again, both individually and collectively as organizations.

And then it is peculiarly the duty of the engineer to see that, so far as in him may lie, these stores of Nature, of which he is the custodian, are used frugally, with due regard to their limited supply, and having in mind the needs of future generations. Again, it is his duty to leave behind him some definite increment to that great store of knowledge through which we are able to enter into partnership with Nature, and only by means of which we may hope to more effectively align ourselves with her laws, and thus maintain an ever-ascending gradient of human progress.

Again we must individually as we may, and collectively with definite purpose, endeavor to coöperate helpfully with agencies charged with the training of recruits for our ranks, to the end that there may be a continued and adequate supply to the younger strata in our guild, whence we may hopefully look for leadership and guidance in the future.

And finally, since in the exercise of his functions as an engineer he must of necessity develop and employ habits of mind and methods of study which may be usefully employed in dealing with problems as they arise in all activities in life, therefore should the engineer stand ready to serve, not only in his chosen sphere, but wherever and whenever his habit of mind, his training, and his experience may enable him to contribute a helpful element in this great coöperative enterprise which we call civilization.

Forty-Sixth Annual Meeting of the A.S.M.E.

Strong, Diversified Program Featured by Initial Thurston and Towne Lectures and Presence of Secretaries of Commerce and War—Twenty-Eight Sessions and Conferences Hold Interest of Members and Bring Out Valuable Discussions

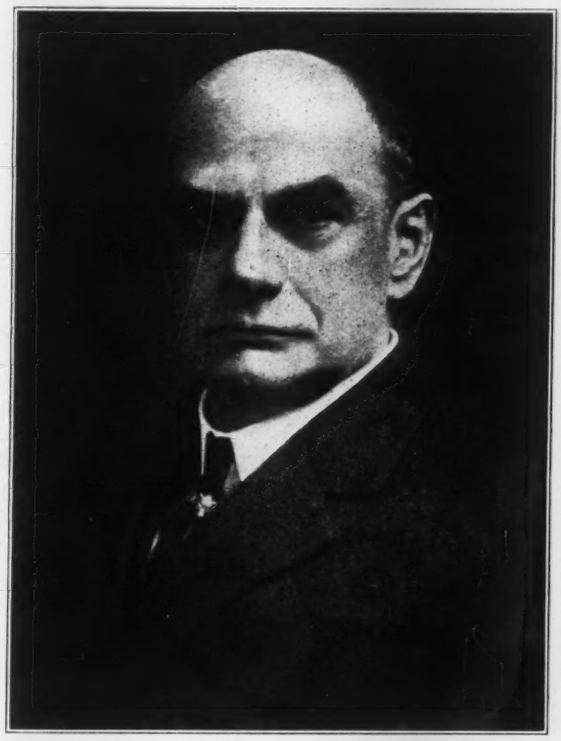
THE FORTY-SIXTH Annual Meeting of The American Society of Mechanical Engineers marked a distinct step forward in the development of the Society's Annual gathering as a great clearing house of inspiration and information in the field of mechanical engineering. Two cabinet officers, two outstanding scientists, and over sixty leaders of engineering and industrial thought participated in a splendid program of addresses, papers, and reports that crowded the five days from November 30 through December 4, 1925, and taxed the resources of the Engineering Societies Building. The registration of 2027 places the meeting among the four largest the Society has ever held.

The features of greatest general interest included the Henry Robinson Towne Lecture by Hon. Herbert Hoover, the presidential address by Dr. William F. Durand, the annual dinner with Dr. M. I. Pupin as the principal speaker, the presentation of a splendid collection of progress and reports by the Professional Divisions, the Robert Henry Thurston Lecture by Dr. Zay Jeffries, the all-day visit to the Bethlehem Steel Company at Bethlehem, Pa., and the session on Industrial Coöperation with the War Department which was presided over by Judge E. H. Gary and addressed by Secretary of War Dwight F. Davis, Assistant Secretary of War Hanford MacNider, Gen. James G. Harbord, and Gen. C. P. Summerall. In addition, the program comprised twenty-eight sessions and conferences, three social events, ten excursions, and forty-eight committee meetings. An important factor in the success of the technical sessions was the large amount of good discussion that was brought out. This was made possible by the comprehensive plan for printing and distributing papers in advance so that the members could have opportunity to study them and prepare discussions. A special issue of MECHANICAL ENGINEERING containing twenty-four papers was mailed to Society members on November 13, seventeen days before the meeting started. The remainder of the papers, printed as pamphlets, were sent out on receipt of orders, a form for which was included in the October 22 issue of the *A.S.M.E. News*. All orders previously received for pamphlets were filled on November 12, and others were shipped daily after that date.

The meeting furnished the usual coöperating sessions with The American Society of Refrigerating Engineers and the Taylor Society, both of which hold their annual meetings during the week of the A.S.M.E. meeting. The session with the A.S.R.E. was devoted to Centrifugal Compressors. The Management Division of the A.S.M.E. conducted two sessions jointly with the Taylor Society which are reported more fully in this account of the meeting. In addition, the Taylor Society held a well-attended meeting on Thursday evening, December 3, which was addressed by William Green, president of the American Federation of Labor, on Labor's Ideals Concerning Management.

PRESIDENTIAL ADDRESS AND AWARD OF HONORARY MEMBERSHIPS

An impressive, brilliant audience filled the auditorium of the Engineering Societies Building on Tuesday evening, December 1, to hear the Presidential Address, to witness the award of Honorary Memberships to two distinguished engineers, and to greet the incoming President of the Society.



W. L. ABBOTT — PRESIDENT, 1926
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Dr. Durand's address as retiring president was a magnificent presentation of the engineer's growth with civilization and his responsibility for the future. It forms a valuable addition to the literature of the profession and will be a source of inspiration for years to come. It appears in this issue of MECHANICAL ENGINEERING as the leading article.

Simple but impressive ceremonies marked the award of Honorary Memberships to Worcester Reed Warner and Herbert Clark Hoover. Mr. Warner was presented to President Durand by Dr. Alexander Humphreys, Past-President of the Society, who briefly related his achievements in astronomical science, in industry, and as a citizen. Mr. Warner responded gratefully to this recognition by the Society, in whose work he had actively participated since its founding. Dr. Fred R. Low, Past-President of the Society, introduced Mr. Hoover to the President as an engineer-statesman who has demonstrated the benefits that may be derived from applying the engineering habit of thought and analysis to the problems of government. Mr. Hoover expressed his deep appreciation of the honor tendered him by his fellow-engineers, saying that the true test of a man was his standing with his professional brethren.

The results of the letter ballot of the membership for the election of officers were announced by David B. Porter, chairman of the Board of Tellers. The following officers were declared elected:

President: WILLIAM L. ABBOTT

Vice-Presidents: A. G. CHRISTIE, WILLIAM T. MAGRUDER, ROY V. WRIGHT

Managers: ROBERT L. DAUGHERTY, WILLIAM ELMER, CHARLES E. GORTON

Representatives on American Engineering Council: WILLIAM L. ABBOTT, JOHN T. FAIG, A. M. GREENE, JR., JOHN L. HARRINGTON, IRA N. HOLLIS, S. H. LIBBY, DEXTER S. KIMBALL, WILLIAM B. POWELL, H. L. THOMPSON.

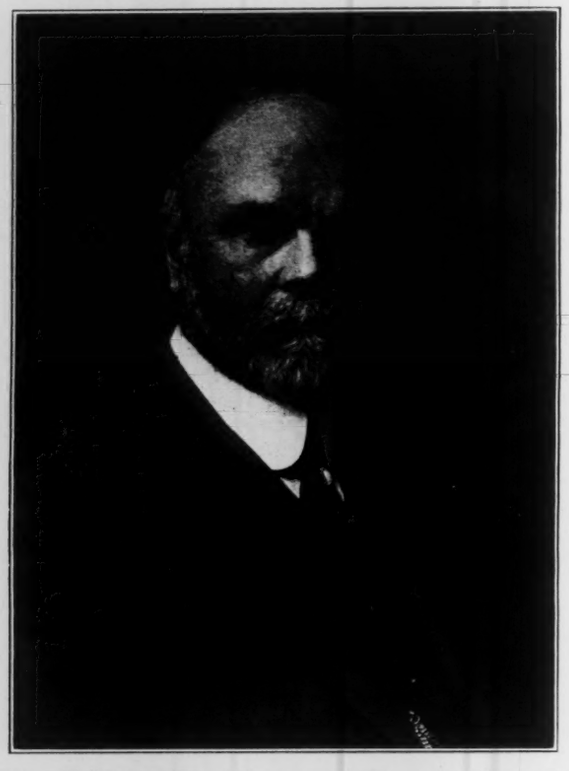
Mr. Abbott, the President-Elect, was escorted to the rostrum by Dr. D. S. Jacobus and Dr. Fred R. Low, Past-Presidents of the Society, and received the gavel from Dr. Durand with an expression of the latter's good wishes for his administration. After a brief acknowledgment of the honor by Mr. Abbott, the gathering adjourned to the fifth floor of the Engineering Societies Building, where the President, the President-Elect, and the two recipients of Honorary Membership were tendered a reception. Dancing followed.

THE TOWNE AND THURSTON LECTURES

Economics and science took their place in the program of the A.S.M.E. Annual Meeting with the institution of the Henry Robinson Towne and Robert Henry Thurston Lectures. If the function of the engineer is to translate the research results of the scientist into benefits for mankind, he will have relations with the scientific world on the one hand and the business world on the other.

These relationships extend through wide zones of indefinite limits, and it is the purpose of the two lectures to give an opportunity for leaders of thought in these zones to present the latest developments to the A.S.M.E. The lecture on the relations between engineering and economics was entitled the Henry Robinson Towne Lecture in recognition of the service which Mr. Towne, a Past-President of the A.S.M.E., rendered in establishing the engineer in the field of management and economics. The science lecture was designated the Robert Henry Thurston Lecture in honor of Dr. Thurston, who as first President of the A.S.M.E. and as a great leader of engineering thought, was instrumental in developing mechanical engineering from a collection of empiricisms into a well-grounded science.

Hon. Herbert Hoover, Secretary of Commerce, delivered the



Worcester R. Warner Who Was Awarded Honorary Membership

first Henry Robinson Towne Lecture on Tuesday afternoon, December 1, 1925 at 4:30 p.m. He took as his subject the Economic Value of Research in Pure Science. The first Robert Henry Thurston Lecture was delivered by Dr. Zay Jeffries, an outstanding metallurgist, on Thursday afternoon, December 3, at 4:30 p.m. The subject was Engineering and Science in the Metal Industry. Both lectures appear in this issue of Mechanical Engineering.

Industrial Coöperation with the War Department

A splendid gathering of engineers, chemists, and manufacturers crowded the Auditorium of the Engineering Societies Building on Friday evening, December 4, to greet the War Department heads and express wholehearted support of the plans for industrial preparedness developed under the National Defense Act of 1920.

The opening event was the presentation of the colors of the 24th Regiment of Engineers to the custody of the United Engineering Society. Lieutenant-Colonel Elliot H. Whitlock, of Cleveland, made the presentation and W. L. Saunders, President of the United Engineering Society, received them. Judge Elbert H. Gary, Chairman of the New York Ordnance District Advisory Board, then took the chair as presiding officer over the program, which included addresses by Hon. Dwight F. Davis, Secretary of War, Hon. Hanford MacNider, Assistant Secretary of War, Gen. James G. Harbord, President of the Radio Corporation of America and Gen. C. P. Summerall, Commanding-General of the Second Corps Area. The addresses are reported on pages 17 to 20 of this issue of Mechanical Engineering.

The Dinner

The dinner at the Hotel Astor on Wednesday evening, December 2, was a huge success, and this event is now well established as the annual reunion of members and the welcoming of the new men into the circle of society friendship. The speaking program was intensely interesting and short, allowing plenty of time for the informal forgathering of old acquaintances. This year ladies were present in goodly numbers, and after the dinner the floor was cleared for dancing.

Samuel H. Libby won fame as toastmaster by his unique introduction of the speakers and the splendid atmosphere of good cheer and professional fellowship that he maintained.

The first part of the program was devoted to the men who had joined the Society during the preceding year, each of whom had an opportunity of meeting the officers of the Society at an informal reception preceding the dinner. First, Dr. Durand introduced the distinguished guests and the past-presidents of the Society who occupied seats at the speakers' table. These included Robert Ridgeway, President of the American Society of Civil Engineers, J. V. W. Reynders, President of the American Institute of Mining and Metallurgical Engineers, Van R. H. Greene, President of the American Society of Refrigerating Engineers, Percy S. Brown, President of the Taylor Society, Past-Presidents Worcester R. Warner, Ambrose Swasey, Jesse M. Smith, D. J. Jacobus, Dexter S. Kimball, John Lyle Harrington and Fred R. Low, and President-Elect W. L. Abbott. Secretary Calvin W. Rice called the roll of 35 new members present and each rose in his place. Past-President Low then addressed the new members, explaining the purpose of the Society, relating its accomplishments, and pointing out the opportunities that it offers for professional comradeships, for encouragement for greater accomplishment, and for broadening the individual's circle of living and opportunity for usefulness.

The principal speaker of the evening was Dr. Michael I. Pupin, President of the American Institute of Electrical Engineers and of the American Association for the Advancement of Science. His remarks consisted of a few stories relating to idealism in engineering, which were told in a simple, impressive way that left a never-to-be-forgotten memory. Those who know of Dr. Pupin's genius as a man of science with a poetical turn of mind looked for something picturesque, and they were not disappointed. By vivid descriptions and anecdotes he carried his audience to the primitive Serbian village where he was born and raised, to the Delaware farm where he learned to manage a pair of stubborn mules, and to the old factory on Chambers street in New York City where he saw for the first time a real steam engine in a real boiler room, which he first entered as a pious pilgrim entering a sacred shrine. He spoke parables of engineering idealism based on these trying experiences of his early days in a manner that raised his audience to a new plane of appreciation of the dignity of the engineering profession.

The Social Program

In addition to the dinner, which was the important social event, there was an informal get-together on Monday evening, November 30, on the fifth floor of the Engineering Societies Building. Here dignity and technicalities were laid aside and an enjoyable three hours resulted.

The Woman's Auxiliary of the Society conducted a splendid program of events for the ladies who attended the meeting. The customary ladies' reception and tea on Wednesday afternoon in the building was an enjoyable occasion. Other events included a get-together gathering on Monday night, a visit to the International House where luncheon was served and tea at New York University on Tuesday, a tour of lower New York on Wednesday morning, and an informal reception and luncheon on Thursday at the Town Hall Club, at which the speaker was P. Whitwell Wilson, a former member of the British Parliament and a journalist of international standing.

During the meeting, ladies from out of town who wished to shop were furnished with guides.

Excursions

The feature excursion of the meeting was the all-day trip to Bethlehem, Pa., on Friday, December 4, to see the works of the

Bethlehem Steel Corporation. About 200 boarded the special train which left Jersey City at 8:30 and returned at 5:30. Luncheon was served by the steel company.

Visits were also made to the De La Vergne Machine Company, the Hellgate Station of the United Electric Light and Power Company, the New York-New Jersey Vehicular Tunnel, the Hudson Avenue Station of the Brooklyn Edison Company, the yards of the Central Railroad of New Jersey to see the new 80-ton Diesel-electric locomotive, the Lee Spring Co., Steinway & Sons, the Edison Lighting Institute, and the Motorship *Gripsholm*.

COUNCIL MEETINGS

The Council met twice during the meeting, its first session being on Monday, November 30. The principal business was the election of John A. Stevens as Honorary Chairman of the Boiler Code Committee in Perpetuity. Mr. Stevens recently resigned as chairman after fourteen years of active service, and this unusual honor by Council is in recognition of his great contribution of time and effort to the work of the Society. A more complete account of the work of the Boiler Code Committee and Mr. Stevens' part in it will be found on another page in this issue.

The date of the Providence Meeting was decided upon as May 3 through 6, 1926. The remainder of the meeting was given over to routine business which lasted through the morning and afternoon.

On Friday, December 4, W. L. Abbott as the new President received the gavel of authority from Dr. Durand and the new members of the Council were installed. Calvin W. Rice was reëlected Secretary. The following were elected as the Executive Committee of the Council: President W. L. Abbott, Past-Presidents Dexter S. Kimball, Fred R. Low and William F. Durand, Vice-President Roy V. Wright, and Manager John H. Lawrence. The remainder of the meeting was given over to the appointment of committee personnel for the ensuing year. The next meeting of the Council will be held January 13, 1926, in Washington, D. C., coincident with the meeting of the American Engineering Council.

LOCAL SECTIONS' DELEGATES CONFERENCE

The conference of delegates from the Local Sections of the Society marked the tenth anniversary of the initiation of the Local Sections movement. The conference occupied all of Monday, November 30, and smaller groups of delegates were in session throughout the meeting. Each Section answered the roll call by giving a short review of the accomplishments of the year. There were also brief addresses by leaders of various Society activities. Under the discussion of Society meetings, the delegates expressed unanimous approval of White Sulphur Springs as the Spring Meeting place in 1927. The delegates of each Section on the route of the A.S.M.E. special train to the San Francisco Spring Meeting in 1926 gave assurance of a hearty welcome.

At noon the members of the Council joined the delegates at luncheon. Mr. Penrose, retiring chairman of the Committee on Local Sections, presided, and Dr. Durand and Mr. Abbott spoke of the splendid work of the Local Sections in advancing the work of the Society.

STUDENT BRANCH CONFERENCE

Forty of the eighty-three student branches were represented at a Student Branch conference held Wednesday afternoon, December 2, following a luncheon meeting with members of the Council. The conference was taken up with the discussion of means of stimulating Student Branch activities and with the presentation of information regarding the work of the Society.

VIEW OF THE 80-TON DIESEL-ELECTRIC LOCOMOTIVE INSPECTED IN THE YARDS OF THE C.R.R. OF N.J. DURING THE ANNUAL MEETING

BUSINESS MEETING—PROGRESS REPORTS

The Business Meeting of the Society, held on Wednesday afternoon, December 2, 1925, was given an unusual flavor by the inclusion of the presentation of reports on progress and prospects in mechanical engineering. The Professional Divisions had prepared a splendid collection of statements covering the field of mechanical engineering. These were printed in full in the December issue of MECHANICAL ENGINEERING and were presented in brief by the representatives of the Divisions. The combined reports will be put to good use as a basis for the future programs of the meetings of the Society, and the selection of research and standardization projects.

During 1925 the Society made an investigation of mechanical-engineering education to assist in the broad, comprehensive investigation of engineering education being carried out by the Society for the Promotion of Engineering Education. The study conducted by the A.S.M.E. consisted of a questionnaire investigation of the membership of the A.S.M.E., to discover the facts concerning the education of the members of the Society and their views in regard to desirable characteristics of mechanical-engineering curricula. This study was conducted by John Lyle Harrington, Frank A. Scott, and W. L. Durand, who represent the A.S.M.E. on the Board of Investigation of the S.P.E.E. At the Business Meeting Mr. Harrington presented the results of the report in brief. The report will appear in more complete form in an early issue of MECHANICAL ENGINEERING.

The bestowal of Society awards has always furnished an occasion of great interest. This year, Dr. Ira N. Hollis, Chairman of the Committee on Awards, opened the ceremony by a brief explanation of the value of the A.S.M.E. awards in developing the power of expression among young engineers. The recipients of the awards were then introduced to the President by Dr. Hollis. The Charles T. Main Award was made to Clement R. Brown, of Washington, D. C., for the best paper on The Influence of the Locomotive upon the Unity of Our Country. His paper appeared in the December issue of MECHANICAL ENGINEERING. The Junior Award was made to Gilbert S. Schaller, Assistant Professor of Engineering Shops, at the University of Washington, Seattle, for his Investigation of Seattle as a Location for a Synthetic Foundry Industry. In Mr. Schaller's absence the prize was given to Prof. E. O. Eastwood, of Seattle. It will later be bestowed upon Mr. Schaller at a meeting of the Western Washington Section of the A.S.M.E. A Student Award was made jointly to William S. Montgomery and E. Ray Enders, both of Pennsylvania State College, for their paper on "Some Attempts to Measure the Drawing Properties of Metal." A Second Student Award was made to Harry Pease Cox, Jr., for his paper on "A Study of the Effect of End Shape on the Towing Resistance of Barge Models."

The routine matters brought up included the annual report of the Council, which was presented by the Secretary, and the reading of the following standards by title:

Safety Code for Elevators, Dumbwaiters, and Escalators (First Revision)

Cold-Finished Shafting, Standard Diameters and Lengths (Transmission and Machinery)

Square and Flat Stock Keys, Standard Widths and Heights.

The following recommendation of the Conference of Local Sections Delegates for the personnel of the Nominating Committee was presented by W. A. Hanley of the Committee on Local Sections and approved by vote of the meeting:

GROUP I—B. S. Lewis, New Britain, Conn. I. E. Moultrop, Boston, Mass., *Alternate.*

GROUP II—J. J. Nelis, New York City. L. B. McMillan, New York City, *Alternate.*

GROUP III—B. M. Brigman, Louisville, Ky. Chas. Loeber, Richmond, Va., *Alternate.* V. L. Sanderson, Philadelphia, *2d Alternate.*

GROUP IV—E. G. Bailey, Cleveland. C. P. Fortney, Charlestown, W. Va., *Alternate.*

GROUP V—C. F. Hirshfeld, Detroit. J. D. Cunningham, Chicago, Ill., *Alternate.*

GROUP VI—Jiles W. Haney, Lincoln, Neb. James M. Robert, New Orleans, *Alternate.*

GROUP VII—R. L. Rockwell, Seattle, Wash. H. L. Doolittle, Los Angeles, Cal., *Alternate.*

The group numbers refer to the geographical groups of the sections which select representation on the Nominating Committee. At a subsequent meeting the Nominating Committee selected C. F. Hirshfeld, of Detroit, Mich., as chairman, and B. M. Brigman, of Louisville, Ky., as secretary.

Following the routine business, John C. Parker, of Philadelphia, Pa., spoke suggesting the encouragement of the discussion of Society policies at the Business Meeting, and Luther D. Burlingame of Providence, R. I., extended a hearty welcome to the Society to the New England Regional Meeting to be held in Providence during the week beginning May 3, 1926.

Technical Sessions

Safety in Industry

TO BRING home to members of the Society their responsibilities in reducing the number of fatalities and injuries due to accidents in industry, President Durand requested each presiding officer at all the sessions on Thursday morning to read a statement of the number of present casualties and to suspend the session and ask the audience to sit in silence for one minute to think on the matter. The result was very impressive. The statement read at the meeting was prepared by C. B. Auel of the A.S.M.E. Safety Committee. It appears in a box in this account of the Annual Meeting.

Oil and Gas Power Session

E. J. KATES, chairman of the Oil and Gas Power Division, presided at the session held under the auspices of that Division on Tuesday morning, December 1. During the session the prize of $100 for the best paper delivered during Oil and Gas Power Week, 1925, was awarded to Commander E. E. Wilson, Bureau of Aeronautics, U.S.A., for his paper on "Power Plants for U. S. Navy Aircraft," read before the Central Pennsylvania Section of the A.S.M.E. at Lewisburg, Pa., on April 18, 1925. The prize was given by the National Committee on Oil and Gas Power Week, representing the technical societies that united in the celebration.

The first paper on the program was that of Dr. Sanford A. Moss on Centrifugal Compressors for Diesel Engines, which appeared in the Mid-November issue of MECHANICAL ENGINEERING. The discussions contributed by A. Peterson, J. L. Haynes, W. E. Ver Planck, L. M. Goldsmith, L. M. Griffith, and Carl Knudsen brought out many points regarding the operation and design of compressors for scavenging and supercharging. They will appear later in more complete form in MECHANICAL ENGINEERING with a closure by Dr. Moss.

An exhaustive treatment of Auxiliaries for Motor Vessels by John W. Morton and A. B. Newell brought forth a wealth of written discussion from Harte Cooke, William H. Thompson, Harold Anderson, Martin L. Katzenstein, James A. Shepard, L. M. Goldsmith, William Mulheron and Joseph Hecking, and oral discussions from John C. Parker, A. W. Robinson, and Spencer Miller. The wide scope of the paper and the many topics treated in the discussion preclude the possibility of abstracting it. The discussions and the authors' closure will appear later in MECHANICAL ENGINEERING, preceded by an abstract of the paper.

The third paper, on Electric Transmission for Internal-Combustion Engines, by Herman Lemp, was not printed in advance, so the author presented it in more complete form. One written discussion by A. Lipetz was also presented. The paper and discussion will appear later in MECHANICAL ENGINEERING.

The paper on The Gas Engines of the Maryland Plant of the Bethlehem Steel Company, by A. A. Raymond, was read by title. It appeared in the Mid-November MECHANICAL ENGINEERING.

Machine Shop Practice (Session I)

THE first session of the Machine Shop Practice Division convened on Tuesday morning, December 1, with the chair occupied by Erik Oberg, member of the Sub-Committee on Meetings and Papers, of the Division.

The Tension Ratio and Transmissive Power of Belts, by C. A. Norman, was the first paper on the program and it elicited an excellent group of discussions revealing a large amount of contemporary research in belting. In the main the discussions dealt with the value of stationary methods of testing belts, and with the difference between belt creep and belt slip. The discussions by Robert V. Drake, E. O. Waters, W. M. Sawdon, R. F. Jones, W. F. Schaphorst, R. R. Tatnall, Selby Haar, and T. A. Bennett will appear in a later issue with the author's closure. An abstract of the paper appeared in December MECHANICAL ENGINEERING.

That the use of optical methods in the machine shop was a topic of importance was shown by the discussion and questions following the presentation of the paper by Henry F. Kurtz, on Principles and Advantages of Optical Methods for Measuring Machine Parts. Mr. Kurtz's paper appeared in the Mid-November MECHANICAL ENGINEERING. In a written discussion C. W. Keuffel[1] traced the rapid advances in the use of optical instruments in industry. He mentioned the stroboscope, used to observe machines in motion, the telescope with attached level to align shafting, periscopes to

[1] Supervisor Optical Dept., Keuffel & Esser Co., Hoboken, N. J. Mem. A.S.M.E.

Annual Meeting Committees

Committee on Meetings and Program

L. B. McMILLAN, *Chairman*
C. N. LAUER, *Vice-Chairman*
E. HOWARD REED
R. M. GATES
S. W. DUDLEY

Representatives of Professional Divisions

Aeronautics
ALEX. KLEMIN
Fuels
M. S. HUTTON
Machine-Shop Practice
W. J. PEETS
Management
C. W. LYTLE
Materials Handling
G. E. HAGEMANN
National Defense
FRANK A. SCOTT
Oil and Gas Power
J. W. MORTON
Power
H. B. REYNOLDS, F. M. GIBSON
Textiles
J. W. COX, JR.
Wood Industries
WM. BRAID WHITE

Staff Representatives

ALEX. KLEMIN
GUY HUBBARD
C. DE ZAFRA
G. A. STETSON
WM. E. BULLOCK

Sub-Committees for 1925 Annual Meeting

EMMETT B. CARTER, *General Chairman*

Reception
L. F. LYNE, JR., *Chairman*
J. W. COX, JR.
J. O. G. GIBBONS
C. H. BERRY
J. W. ROE

Information
A. J. SICREE, *Chairman*
E. BRAMBLE
W. FRIGIOLA

Courtesy
GEO. F. FELKER, *Chairman*
ROSWELL MILLER
E. B. MEYER
A. W. LENDEROTH

Excursions
L. H. WELLING, *Chairman*
R. A. WRIGHT, *Vice-Chairman*
H. D. SAVAGE
R. G. ADAMS
R. S. AUSTIN
E. E. JACKSON

Open House
V. M. FROST, *Chairman*
A. A. ADLER
F. M. VAN DEVENTER
J. E. STRAIN
R. S. AUSTIN

President's Reception
CLYDE R. PLACE, *Chairman*
CLOYD CHAPMAN
S. H. LIBBY
WILLARD BRINTON
JOHN PRICE JACKSON

Dinner
FRED R. LOW, *Chairman*
W. F. M. GOSS
ROY V. WRIGHT
W. S. FINLAY, JR.
JOHN H. LAWRENCE
J. W. ROE
CLARKE FREEMAN
B. C. McCLURE
FREDERICK SCHEFFLER

Catering
WARREN D. LEWIS, *Chairman*
W. M. KEENAN
ROBERT JOHNSON

Ladies' Committees
MRS. R. V. WRIGHT, *General Chairman*
MRS. C. B. LEPAGE, *Chairman, "Get-Together"*
MRS. L. R. GURLEY, *Chairman, Information and Excursion*
MRS. R. M. GATES, *Chairman, Hospitality*
MRS. G. L. KNIGHT, *Chairman, Luncheon*

examine the inside of tubes, and polarized light to investigate stresses and strains in members both fixed and moving under load. W. J. Peets[2] hailed optical methods as a distinct advance in precise machine work. He favored an optical comparator with gage blocks in place of a graduated scale which required shop correction factors and which brought in aging, temperature, and wear factors that made shop use difficult. D. R. Miller[3] directed attention to the fact that accurate results could be obtained more quickly by comparative than by direct measurements. He also cautioned against the use of a glass plate over a metal scale, as distortion might result. H. W. Bearce[4] pointed out that accuracies of a few millionths of an inch could be obtained only with relative measurements involving but small differences of dimensions. This was true because there was no basic relation between wave lengths and inches or between meters and inches. He advocated the definition of both the yard and the meter in terms of light waves so that the inch would equal 25.4 millimeters. R. E. Flanders[5] emphasized the advantage of the projection method in production inspection, especially in screw threads, where the projection method permitted the simultaneous visualization of all the variables that affected the fit of the screw. This also applied to the inspection of gears where the actual contour could be compared with the desired contour without the use of figures and calculations. G. M. Eaton[6] called attention to the opportunity for developing devices for measuring machine elements in motion. He mentioned the oscillograph as an illustration of the light lever and stated that instruments had been developed for recording the stress cycle in the connecting rod of a locomotive which for a stress of 15,000 lb. per sq. in. was accurate to 500 lb. In his closure, Mr. Kurtz stated that variations in scales could be quickly checked by gage blocks. Invar was generally used for scales as it had a zero temperature coefficient. He also pointed out that for the projection method of inspecting gears, the apparatus would vary greatly with the size of the parts to be inspected.

[2] Engineer in Charge of Factory Methods, Singer Mfg. Co., Elizabethport, N. J. Jun. A.S.M.E.
[3] Bureau of Standards, Washington, D. C.
[4] Bureau of Standards, Washington, D. C.
[5] Manager, Jones & Lamson Machine Co., Springfield, Vt. Mem. A.S.M.E.
[6] Chief Mechanical Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa. Mem. A.S.M.E

Wood Industries Session

THOMAS D. PERRY, past-chairman of the Wood Industries Division, presided at the session held under the auspices of that Division on Tuesday morning, December 1. In opening the session he told of the genesis of the Division, based on the strong conviction that the interrelation between engineers and woodworkers was poor. The excellent program for this session was proof that the field for coöperation was broad and fruitful.

The discussion at the session will be reviewed and presented in a later issue of MECHANICAL ENGINEERING. The papers presented were: The Electric Molder, by Andrew Jensen, Jr.; Scientifically Developed Shipping Containers, by C. M. Bonnell, Jr.; High-Speed Induction Motors and Frequency Changers, by Charles Fair; Recent Advances in Methods of Glue Evaluation, by Wilbur L. Jones; and Spark Arresters and Forest Fires, by J. S. Mathewson. The first four papers appeared in the Mid-November MECHANICAL ENGINEERING.

At the close of the session, Chairman Perry gave an informal report of a questionnaire study made by the Wood Industries Division to determine the extent of woodworking education for cultural, vocational, and engineering or scientific purposes. A tabulation of the replies received will be presented later in MECHANICAL ENGINEERING.

Public Hearing on Test Code for Steam Turbines

C. HAROLD BERRY, as chairman of the Individual Committee on Power Test Code for Steam Turbines, presided at the public hearing convened on Tuesday morning, December 1, at which the Code for Steam Turbines was presented for criticism. The public hearing is a regular step in the procedure of preparing A.S.M.E. Test Codes. The comments brought out at the hearing will be carefully considered for incorporation in the Code, which will then be reprinted and, after approval of the Main Committee on Power Test Codes, presented to the Council as a standard practice of the Society.

Session on Industrial Power

THE problems of generating power in industrial establishments were taken up in a session on Tuesday afternoon, December 1, under the auspices of the Power Division, Past-President Fred

R. Low presiding. The two papers presented brought out a wealth of discussion and indicated that the Power Division has a field of great importance in its sessions on industrial power.

The first paper, on The Value of Higher Steam Pressures in Industrial Plants, was presented by William F. Ryan, and written discussions were submitted by J. R. McDermet, R. E. Hall, Guy B. Randall, W. G. Diman, Harold Anderson, H. G. Barnhurst, A. J. German, E. D. Dickinson, Alexander M. Ormond, and Hans Dahlstrand. These discussions consumed all the time that was allowed for the purpose, but the interest shown in the subject was so great that it was orally discussed by a large number after the consideration of the second paper. Mr. Ryan's paper appears in slightly abridged form in this issue of MECHANICAL ENGINEERING. The discussion will be summarized in a later issue.

The second paper, on the Supply of Industrial Power, was presented by William Harrison Larkin, Jr., and discussed by N. E. Funk, Henry F. Scott, and J. C. Parker. Mr. Larkin's paper appeared in the Mid-November issue of MECHANICAL ENGINEERING. An abstract of the discussion will be published in a later issue.

Session on Centrifugal Compressors

VAN R. H. GREENE, president of the American Society of Refrigerating Engineers, was the presiding officer at a joint session held with the A.S.R.E. on Tuesday afternoon, December 1. The first paper, by M. G. Robinson, dealt with The Heat-Balance Method of Testing Centrifugal Compressors. A written discussion by M. S. Petersen was presented. In the general discussion which followed S. A. Moss and W. H. Carrier participated. An abstract of the paper with a brief account of the discussion will appear in a later issue of MECHANICAL ENGINEERING.

The next paper presented was one by W. H. Carrier, on Centrifugal Compression, which will be published in *Refrigerating Engineering*, the Journal of the A.S.R.E. The author's aim was to present the fundamental characteristics of centrifugal refrigerator performances in a clearer way than had heretofore been done.

He gave first a brief résumé of the principles involved in centrifugal refrigeration, and warned against the tendency to confuse a centrifugal compressor either with a rotary compressor or with a reversed steam turbine.

While the exact mathematical analysis of the process of centrifugal compression was difficult and complicated, fortunately there was a simpler method of attack to which the author called attention, consisting in the division of the process into two distinct features as follows:

1 Consideration of the energy transferred to the gas by means of suitable impellers and of the corresponding theoretical and actual heads produced

2 The study of the properties of a gravitational column of gas to which the corresponding heads might be referred.

The same methods employed in computing the head of water produced by a centrifugal pump were applicable to a centrifugal compressor handling a compressible gas.

The following topics were discussed in the paper: Properties of a gas in a gravitational column; head produced by centrifugal action; head produced by tangential velocity; effect of blade shapes; ratio of compression; relation of temperature range to speed; and finally, the performance characteristics in centrifugal refrigeration.

In the general discussion of Mr. Carrier's paper the following participated: H. Emerson, A. J. Wood, S. A. Moss, and F. P. Anderson. The discussion brought out the fact that the author's presentation of the problem was quite novel, although leading in the end to the same mechanical and thermodynamical equations.

Dean Anderson, of the University of Kentucky, characterized the whole paper as very ingenious and said that the interesting and valuable analogy of the gravitational column of gas to the mythical column extending from near the center to the periphery of the centrifugal compressor, gave the engineer a very simple approach to centrifugal compressor problems.

In answer to a question by Dr. Moss, the author stated that the actual diameters of the machine's impeller varied from thirty to twenty-four inches and that about fifty such centrifugal compressors were in operation.

Before the adjournment of the meeting, at 4:45 p.m., F. E. Mathews made a short report on the activities of the National Research Council. Projects having to do with heat transmission, that were of particular interest to refrigerating engineers were briefly reviewed, and the following motion was made and carried:

Resolved, That the A.S.M.E. and A.S.R.E. be formally requested by this assembly to appoint members to a Joint Conference Committee to draft a formal request to the National Research Council to assist in the organization of a Committee to develop ways and means of carrying out a program for the determination of the physical constants of the principal refrigerants.

Session on Calculation Methods

A NOVEL session on Calculation Methods was held on Tuesday afternoon, December 1, with Prof. A. G. Christie, member of the Council of the Society, as presiding officer.

Two papers were presented, one by Prof. Herbert L. Seward, on Graphical Methods of Calculation, and one by G. W. Greenwood, on The Making of Special Slide Rules. References to diagrams in the preprints of the papers and to blackboard sketches cannot be reproduced readily, and much of interest in a discussion of which they form a part is therefore impossible to report. However, the discussion will be prepared for later publication in MECHANICAL ENGINEERING. Both of these papers appeared in the Mid-November issue.

Session on Industrial Furnaces

O. P. HOOD, chairman of the Fuels Division, presided at the session on Industrial Furnaces held under the auspices of the Fuels Division on Wednesday morning, December 2. The session inaugurated a program of discussion on Industrial Furnaces, a subject which has heretofore been neglected in the Society meetings.

The papers by W. Trinks and Victor J. Azbe, on Industrial Furnaces and on Industrial Furnace Efficiency, respectively, were printed in the Mid-November MECHANICAL ENGINEERING. They drew forth prolific discussion at the meeting, which thoroughly covered the field of industrial-furnace design and operation and suggested many topics for presentation at future meetings of the Society and for basic researches in the problems involved. The discussion will be reported in a later issue of MECHANICAL ENGINEERING.

Machine Shop Practice (Session II)

W. F. DIXON, chairman of the Machine Shop Practice Division, presided at the second session held under the auspices of the Division on Wednesday morning, December 2. The first part of the session was given over to gears with the presentation and discussion of two papers one, by Messrs. Marx, Cutter, and Green, recording Some Comparative Wear Experiments on Cast-Iron Gear Teeth, and a second, by G. M. Eaton, on Normal Pitch—The Index of Gear Performance. These two papers appear in abridged form in this issue. The discussion will follow later.

The second part of the session was given up to a discussion of Forrest E. Cardullo's paper on The Question Mark in Machine Design, which was published in Mid-November MECHANICAL ENGINEERING. Prof. A. L. Jenkins[7] presented the paper and John D. Riggs[8] submitted a written discussion in which he asked if in the open-side machine frame of Fig. 3 there would not be excessive stress at the intersection of the vertical flange with the horizontal flange. He also pointed out that spongy material weakened these intersecting flanges and suggested that the best way to determine the best design of such a frame was to test small models to destruction. Mr. Cardullo had furnished a written reply to Mr. Riggs's criticism in which he pointed out that the resultant of the horizontal and vertical stresses was greater than each, but that it acted against a greater cross-section of metal. Professor Jenkins pointed out the difficulties of designing shafts with keyways and stressed the practical commercial results that must be secured in completed machines, many of which did not permit of rational analysis. Professor Jenkins' statements about shafts with keyways brought out several replies, among them one mentioning the Sectional Committee on Standardization of Shafting, which

[7] Professor of Mechanical Engineering, University of Cincinnati, Cincinnati, Ohio. Mem. A.S.M.E.

[8] Designer, Indianapolis, Ind. Jun. A.S.M.E.

permits 15 per cent deduction from the strength of the full shaft for a keyway with a width equal to one quarter of the diameter. J. H. Billings[9] stated his belief that real progress in machine design could not be made by disregarding the best statements of natural laws now available, even though we knew they were faulty.

Session on Materials Handling

THE Session on Materials Handling was held Wednesday morning, December 2, under the auspices of the Materials Handling Division and the A.S.M.E. Safety Committee. James A. Shepard, chairman of the Materials Handling Division, presided.

The first paper, by F. D. Campbell, on Materials-Handling Problems and Their Solution, appeared in the Mid-November MECHANICAL ENGINEERING. The discussions presented by H. V. Coes, C. A. Burton, M. H. Landers, G. E. Hagemann, F. E. Moore, M. W. Potts, W. F. Hunt, L. P. Alford, J. L. Haynes, and R. H. McLain dealt with the economic problems involved in the selection of materials-handling apparatus, the allocation of overhead expenses to materials-handling equipment, and a correct sales policy.

The second paper of the morning, on Safety in Materials Handling, was presented by David S. Beyer. The discussion, which emphasized the need of tabulating accident information, the need for standards of inspection, and the desirability of designing equipment using the elastic limit of materials rather than the ultimate strength with a safety factor was contributed by L. A. DeBlois, J. P. Jackson, M. Lund, A. D. Risteen, H. V. Coes, and R. H. McLain.

An abstract of Mr. Beyer's paper with the discussion will appear in a later issue of MECHANICAL ENGINEERING, as will also an abstract of the discussion on Mr. Campbell's paper.

At the close of the session James A. Shepard presented a Report on the Application of Materials Handling Formulas which had been derived by a special committee of the Materials Handling Division for use in selecting the most economical types of materials-handling equipment to fulfil a given purpose.

Session on Springs

THE first stages of the work of the Special Research Committee on Metal Springs include a study of the present state of the art of spring design, manufacture, and use. The progress in this study was revealed by several papers which were presented at the Session on Springs on Wednesday morning, December 2. Joseph K. Wood, chairman of the Research Committee on Metal Springs, presided. The program consisted of the following papers: Phosphor-Bronze Helical Springs from the Standpoint of Precision Instruments, by W. G. Brombacher; The Manufacture of Commercial Steel Helical Springs, by F. H. Brown; Characteristics of Weighing Springs, by J. W. Rockefeller, Jr.; Springs for Electrical Measuring Instruments, by B. W. St. Clair; Formulas for the Design of Helical Springs of Square or Rectangular Steel, by C. T. Edgerton; An Outline for the Application of Fatigue and Elastic Results to Metal Spring Design, by T. McLean Jasper; and The Ring Spring, by O. R. Wikander. The papers by Messrs. Brown, Rockefeller, and St. Clair appeared in the Mid-November MECHANICAL ENGINEERING. Abstracts of the other papers will appear in a later issue with the discussion.

Session on Education and Training for Industries of Non-College Type

AT THE Session on Education and Training for Industries of the Non-College Type, held on Wednesday afternoon, December 2, Prof. John T. Faig officiated as chairman. The first speaker introduced by him was Dr. William E. Wickenden, director of investigation, Society for the Promotion of Engineering Education. Dr. Wickenden had just returned from a visit to the industrial districts of Central Europe, including those of Czechoslovakia. Taking as the subject of his talk the title of the session itself, he gave a most interesting account of his European findings. The general conclusion to be drawn was that in all of the industrial countries in Europe more attention was being given both to the training methods and to the choice of those to be trained. Candidates for trades and professions of an engineering character were selected in the lower schools by the capabilities revealed in preliminary studies. Once in their proper field there was really no limit to the point they might attain—if they had unusual ability. However, the courses were so arranged that one fitted to be a toolmaker would be graduated into industry as a toolmaker, or one fitted for any other trade would go out with his education complete in this respect. On the other hand, there were at all points in the various trade courses and engineering courses means by which a student who proved to be unusually brilliant might "bridge across" (to use the words of Dr. Wickenden) into a higher trade or professional course more worthy of his attainments. Thus, while the different courses ran independently of each other, a man was by no means confined to one parallel line if his attainments would carry him further than that line extended.

The other speaker at this session was Dwight L. Hoopingarner, director of the New York Building Congress. His paper was entitled The Apprenticeship Movement and Its Relation to the Building Trades. He brought out the fact that there were many forces coöperating in training boys for the various building trades, and that the unions were vitally interested and very active in carrying along this training successfully. He stated that there were peculiar factors affecting the building field which those outside of it did not always take into account inco nsidering training for it. Building was a more or less seasonable business and oftentimes a fluctuating one. When the unions trained a quota of apprentices based upon present needs, this quota frequently proved to be, by the time training was complete, larger than the employers could make immediate use of. This was due to the fact that the contractors themselves had to frequently look for new jobs upon the completing of the ones which they had been engaged in. In this respect their condition was but little different from that of labor. Until contractors got relocated they could not carry a working force of any size upon the payroll. Having in mind that there was a possibility that the country was now at the peak of the demand for buildings, Mr. Hoopingarner said that the future needs over a period of years should be carefully forecast before a largely increased number of young men were urged to enter upon a two, three, or even four years' course as builders. Not only was it important that these young men should have work throughout their training period, but it was still more important that they be training for a job which would still exist at the end of their training. Serious consideration was being given to this "establishment of employment" by the New York Building Congress, which was made up of real-estate men, manufacturers and distributors, designers, architects, engineers and contractors, all related industries, and labor. With a national organization along the same lines also functioning, it was hoped that an intelligent and conservative program of training would be worked out and maintained.

Session on Steam Properties Research

THE annual discussion on the investigation of the properties of steam now being carried on by the Society, was held on Wednesday afternoon, December 2, with Dr. A. M. Greene, Jr., member of the Executive Committee of the Steam Table Fund, as presiding officer.

Preceding the technical discussion, Geo. A. Orrok, chairman of the Executive Committee of the Steam Table Fund, presented a brief report. The work being carried out by the Bureau of Standards was reported by N. S. Osborne, the progress at Massachusetts Institute of Technology was related by Dr. L. B. Smith, and the work at Harvard University was discussed by Dr. R. V. Kleinschmidt. Dr. F. G. Keyes then expanded on the remarks by Dr. Smith as to the progress at Massachusetts Institute of Technology. A progress report on the development of steam charts and tables from the Harvard throttling experiments was presented by J. H. Keenan. This included a total-heat entropy diagram based on data taken from the Joule-Thomson tests conducted by Dr. Harvey N. Davis and Dr. R. V. Kleinschmidt at Harvard University.

The closing event of the afternoon was a discussion by Dr. Harvey

[9] Professor of Mechanical Engineering, Drexel Institute, Philadelphia, Pa. Mem. A.S.M.E.

N. Davis of the future of the program of research. All the progress reports presented at the session, including that of Mr. Keenan's with its Mollier diagrams and tables, will appear in the February issue of MECHANICAL ENGINEERING.

Session on Steam Power

THE Steam Power Session was held Thursday morning, December 3, under the auspices of the Power Division, with Frank S. Clark, chairman of the Power Division, acting as presiding officer. There was the usual crowded auditorium and excellent program of discussion.

The first paper, by Charles W. E. Clarke, revealed Recent Developments at Colfax Station. Mr. Clarke's paper appears in abstract in this issue. The discussion—presented by Prof. F. O. Ellenwood, H. W. Leitch, C. D. Zimmerman, R. J. S. Pigott, and Joseph S. Bennett—will appear in a later issue of MECHANICAL ENGINEERING.

The second paper, by Carl D. Zimmerman, gave results of Steam Bleeding and Turbine Performance. This was discussed by F. O. Ellenwood, M. K. Drury, Charles W. E. Clarke, W. J. Wohlenberg, C. G. Spencer, and F. M. Van Deventer. Mr. Zimmerman's paper appeared in MECHANICAL ENGINEERING for December. The discussion will appear in a later issue.

Radiation in Boiler Furnaces was the subject of a paper by B. N. Broido, which was discussed by Geo. A. Orrok, A. G. Christie, W. J. Wohlenberg, H. H. Suplee, E. H. Tenney, and Andrew Bato. The paper with an abstract of the discussion will appear in a later issue of MECHANICAL ENGINEERING.

The final paper was one by R. Sanford Riley and Ollison Craig, on The Development of a Unit Pulverizer, and was presented by Mr. Craig. This paper was published in the Mid-November issue; the discussion, which was voluminous, will appear in a later issue of MECHANICAL ENGINEERING.

Management Session

THE joint session of the Management Division and the Taylor Society was held on Thursday morning, December 3. Robert T. Kent, chairman of the Management Division, presided.

Three papers were presented which brought out a large amount of stimulating discussion. The Influence of Plant Design on Plant Efficiency was the subject of a paper by Harold T. Moore, which was presented in his absence by Alfred Iddles. Production Control in the Newsprint Industry was presented by George D. Bearce, and Carbon Dioxide as an Index of Fatigue, by Walter N. Polakov. The papers by Messrs. Moore and Polakov were published in the Mid-November MECHANICAL ENGINEERING. Discussion on these papers will appear in a later number. An abridgment of Mr. Bearce's paper will be found elsewhere in this issue, together with an abstract of the discussion.

A resolution reaffirming the recognition of management as a measure of engineering and requiring that the teaching of industrial engineering and/or management engineering should be taught by schools of engineering, was adopted by the meeting.

Session on Aeronautics

THE session on Aeronautics convened on Thursday morning, December 3, with Grover Loening as presiding officer. In opening the session the chairman called attention to the report of the President's Aircraft Inquiry which had appeared in the morning papers. He paid tribute to the careful and impartial investigation of the aircraft situation which had resulted in the report.

W. L. LePage presented the papers by Lieut-Col. H. H. Blee on The Airship and Its Place in Commerce, and by Lieut. Ernest W. Dichman on Maintenance and Depreciation of Airplanes and Engines. The discussion on Lieut. Dichman's paper brought out the advantages of the air-cooled airplane engine over the water-cooled in the shorter time necessary for overhaul and the lower maintenance cost.

The final paper of the morning was a report of Technical Progress at McCook Field by Lieut. E. E. Aldrin. Lieut. Aldrin's and Lieut. Dichman's papers will appear in a later issue of MECHANICAL ENGINEERING with an abstract of the discussion at the session. Colonel Blee's paper appeared in the Mid-November MECHANICAL ENGINEERING.

Session on Textiles

THE session on Textiles was held on Thursday morning, December 3, under the auspices of the Textiles Division, with George H. Perkins, chairman of the Division, presiding.

The opening paper, by W. A. Mayor, treated of Individual Motor Application to Woolen and Cotton Card Machinery. It elicited spirited discussion, as did also the second paper, by Charles T. Main, on Power for Textile Mills. In Mr. Main's absence, his paper was presented by A. W. Benoit. These papers with the discussion will appear later in MECHANICAL ENGINEERING.

SOCIETY PLEDGES ITSELF TO AID IN ACCIDENT PREVENTION

THE accident situation in this country has reached appalling proportions, taking an annual toll of approximately 80,000 lives, while disabling over 2,000,000 more for varying periods. This yearly loss is greater than that sustained by our armies during the entire period of the World War, and has become still more serious in several of its aspects.

Compared with other nations, there are killed in peaceful America per million of population almost twice as many as in France or Japan, more than twice as many as in Great Britain, and four times as many as in Denmark.

The direct loss has been estimated to run each year into the billions of dollars, while the indirect loss is beyond calculation, and our country is now confronted with a problem, already sufficiently grave, which may ultimately prove to be the greatest in its history.

Additional to and dwarfing all such losses, however, are the human suffering and misery engendered, the extent of which none can either measure or conceive, but which must exert an increasingly retarding effect on the advancement and uplift of our country and bring a stain upon it which can never be effaced.

The members of this Society, therefore, in recognition of the situation, which calls for the best efforts of every citizen having the welfare of our country at heart, pledge themselves and this Society to continued and unremitting effort in this greatest of all human endeavor—the work of accident prevention.

At the request of President Durand, there was read at each simultaneous session of the Annual Meeting on Thursday morning, December 3, the foregoing statement presenting a critical situation in the industrial and engineering life of our country. Each session was declared suspended for a period of one minute for the quiet consideration of the gravity of the accident losses with which the country is confronted, and the acceptance of the pledge outlined was indicated by those in attendance remaining silent for that period.

Session on Power-Plant Materials

THE session on power-plant materials, held under the auspices of the Power Division, convened on Thursday afternoon, December 3, with C. F. Hirshfeld, chairman of the Special Research Committee on Refractories, presiding.

The first two papers related to metals used in the power plant. Albert E. White discussed Heat-Treatment Data on Quality Steel Castings, and William P. Wood took up the subject of Bolts for Use in Power-Plant Construction. Professor Wood's paper appeared in the Mid-November MECHANICAL ENGINEERING, and the discussion on it will be published with an abstract of Professor White's paper in a later issue.

The closing paper was one devoted to Boiler-Furnace Refractories, by E. B. Powell. Mr. Powell's paper with the discussion will appear in a later issue of MECHANICAL ENGINEERING.

Session on Lubrication

THIS session was held under the auspices of the Special Research Committee on Lubrication on Thursday afternoon, December 3, with A. E. Flowers, member of the Special Research Committee on Lubrication, presiding.

The two papers which were presented were thoroughly discussed. They will appear in abstract with the discussion in a later issue of MECHANICAL ENGINEERING. The first paper—Graphical Study of Journal Lubrication (Part III), by H. A. S. Howarth, was a continuation of an investigation of journal lubrication reported to the Society under the same title in 1923 and 1924. The second paper—Charts for Studying the Oil Film in Bearings, by George B. Karelitz, aims at giving the designer a means of determining with sufficient accuracy the shape and pressures in the oil film for bearings under different conditions.

Session on Industrial Psychology

INDUSTRIAL psychology was the subject of a joint session of the Taylor Society and the Management Division of the A.S.M.E. on Thursday afternoon, December 3. Percy S. Brown, president of the Taylor Society, presided.

The first paper, by Lillian M. Gilbreth, was entitled The Present State of Industrial Psychology. It appeared in the Mid-November MECHANICAL ENGINEERING. The second paper, by Edgar A. Doll, related to Psychology in the Organization of Prison Industries. In the discussion which followed Prof. Harry Dexter Kitson[10] discussed job analysis as the point of application for psychology. He suggested that for any job analysis to conform to regulated requirements of scientific psychology must follow certain principles. The requirement of a job must be studied in terms of the work involved on the job. The analysis must be made in terms of quantity as well as quality. Methods must be used that would evoke demonstrable facts. In conclusion, he deplored the tendency to make analyses in terms of general abstract opinions.

Donald A. Laird[11] asked that increased emphasis be given to the use of engineering data in the motivation, training, and contentment of the worker. He reported the work being done by the Industrial Fatigue Research Board in England which had demonstrated the manner in which laboratory results might be utilized in the factory. He stated that psychology needed to have the help of industry so that there would be fewer opinions offered from the armchair and fewer laboratory data that could not be used.

Wallace Clark[12] pointed out that the group of men and women who composed the management formed a complex field for the psychologist. The engineer needed the help of the psychologist in analyzing methods and in opening men's minds to a better understanding of others.

Dr. William N. Thayer[13] stated his belief that in institutional work the worker was of more importance than the work he performed. He related the problems facing institutions in rehabilitating men from the physical and social standpoint.

Robert T. Kent[14] compared the conduct of prisons of New York State with manufacturing institutions. He stressed the need for an incentive and the importance of teaching the inmate how to work.

C. S. Yoakum[15] stated the need for the psychologist in industry. He advocated closer contact of the psychologist with shop conditions and the willingness on the part of the psychologist to work to coarser tolerances.

John Younger[16] emphasized the importance of the need for flexible standards as many people forgot that standardization represented today's knowledge and not the increased knowledge of tomorrow.

Walter N. Polakov[17] presented a suggested classification of abnormal types of persons and advocated that to each be given a task in accord with his capacity. He advocated the keeping of individual man records as a means of securing an approach to desired goals.

Richard A. Feiss[18] spoke of the great value of training individuals as a factor in the solution of industrial problems of the future.

Dean J. A. Burdsley[19] related the manner in which at the University of Michigan each prospective freshman was interviewed to determine his fitness for the course of training he selected.

Dr. W. R. Bingham[20] spoke of the importance of adequate engineering measurements of output and individual performance as the basis for checking experimental work of the psychologist.

Morris S. Viteles[21] spoke in favor of having a completely trained psychologist in industry instead of instructing the managerial staff in psychology.

Session on Design

E. O. EASTWOOD, Manager of the Society, presided at this session, which was held on Thursday afternoon, December 3.

The first paper presented was on Torsional-Stress Concentration in Shafts of Circular Cross-Section and Variable Diameter, by L. S. Jacobsen. The object of this paper was to point out an electrical experimental method for finding the torsional-stress distribution in cylindrical shafts of any axial outline. A series of curves was given to enable the designer to find at a glance, the maximum torsional stress in a shaft of two diameters for various diameters and fillet proportions.

In the absence of the author the paper was presented by Dr. S. Timoshenko. In the discussion A. L. Kimball, Jr.,[22] pointed out that the paper appealed to him as a very interesting contribution to the field of applied elasticity and of much practical importance as no exact mathematical solution was available, and furthermore the problem could not be exactly solved by the photoelastic or polarized-light method since the stress varied in all three dimensions.

The next paper was on Tangential Vibration of Steam-Turbine Buckets, by Wilfred Campbell (deceased) and W. C. Heckman. Research in axial vibration was reported to the Society at the 1924 Spring Meeting. The extension of this research to cover tangential vibration formed the subject of this paper.

Written discussions were presented by G. L. Knight,[23] B. Fox,[24] and S. H. Weaver.[25] These discussions gave results of various experiments conducted along similar lines and emphasized the importance of the problem, stating that the influence of the bucket frequency had generally not been fully appreciated, particularly in connection with the problem of estimating the frequency of the wheel.

S. A. Moss and S. Timoshenko particiated in the oral discussion.

The last paper presented, by A. L. Kimball, Jr. and E. H. Hull, dealt with Vibration Phenomena of a Loaded Unbalanced Shaft While Passing through Its Critical Speed. This paper was a discussion, with an experimental demonstration, of the peculiar vibration phenomena to which an unbalanced, loaded shaft is subjected while passing through its critical speed.

Written discussions were contributed by S. Timoshenko, Prof. E. O. Waters, Prof. P. Heymans,[26] H. D. Taylor, and Burt L. Newkirk.

The presentation made by the authors was characterized by Prof. Heymans as a simple theory of the action of *external* friction forces on the whirling of rotating shafts. The authors, he said, had substantiated their theory by skilful experiments. In its present form, however, the theory could not be extended to *internal* frictional forces.

The Exposition of Power and Mechanical Engineering

THE Fourth National Exposition of Power and Mechanical Engineering attained the ideals of its originators in its diversity and well-planned display of valuable exhibits of power and mechanical-engineering apparatus. In the number of exhibits, the range of subjects, the attendance, and the enthusiasm of both

[10] Professor of Education, Teachers' College, Columbia University.
[11] Editor, *Industrial Psychology*.
[12] Consulting Management Engineer, New York. Mem. A.S.M.E.
[13] Institute for Defective Delinquents, Napanoch, New York.
[14] Superintendent Prison Industries, New York State. Mem. A.S.M.E.
[15] Personnel Department, University of Michigan.
[16] Professor of Industrial Engineering, Ohio State University. Mem. A.S.M.E.
[17] President, Walter N. Polakov & Co., New York. Mem. A.S.M.E.
[18] Vice-President, Joseph & Feiss Co., Cleveland, Ohio. Assoc. A.S.M.E.
[19] University of Michigan.
[20] Director, Personnel Research Association.
[21] University of Pennsylvania.
[22] Research Engineer, General Electric Co., Schenectady, N. Y. Assoc. A.S.M.E.
[23] Brooklyn Edison Co., Brooklyn, N. Y. Mem. A.S.M.E.
[24] Fore River Plant, Bethlehem Shipbuilding Corp., Ltd., Quincy, Mass. Mem. A.S.M.E.
[25] General Electric Co., Schenectady, N. Y.
[26] Assistant Professor of Theoretical Physics and Photoelasticity, Massachusetts Institute of Technology, Cambridge, Mass. Assoc-Mem. A.S.M.E.

(*Continued on page 88*)

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

The American Society of Mechanical Engineers

29 West 39th Street, New York

W. L. ABBOTT, *President*
ERIK OBERG, *Treasurer* CALVIN W. RICE, *Secretary*

PUBLICATION COMMITTEE:
O. G. DALE, *Chairman* K. H. CONDIT
RALPH E. FLANDERS E. D. DREYFUS
W. A. SHOUDY

PUBLICATION STAFF:
C. E. DAVIES, *Managing Editor*
FREDERICK LASK, *Advertising Manager*

Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

BY-LAW: The Society shall not be responsible for statements or opinions advanced in papers or.....printed in its publications (B2, Par. 3).

The Doctor-Engineer Scans Civilization

DR. DURAND'S Presidential Address combined a survey of the romantic antiquities of the engineering profession, a modest enunciation of the place of the engineer in the progress of civilization, and a statement of the duty of the engineer of today. They form a delightful essay for study by every engineer who glories in the tradition of his profession and who faces its responsibilities with a stout heart. But in the midst of this inspiring paper, he asked some searching questions. From his pinnacle he scanned the past and searched the future and then he pondered, "Have engineers vision? Have they well-defined objectives? Have they the coöperative spirit? Have they all of these elements that are necessary if their contribution is to be of lasting value?" The answers he leaves to us. But he touched one vital spot in treating of engineering education and the need for a better understanding between the teaching side and the practicing side of the profession. He bespeaks the wholehearted support of the engineering societies in this vital matter to the future of engineering progress. Our next generation of leaders must have the vision and the understanding, for our achievements are limited only by our vision.

Dr. Durand dignified the engineering method by the use of the phrase "grand strategy," which ought to have a permanent place in our literature. Its use should be guarded so that it may not become threadbare, but it should be in the mind of the engineer when he attacks his own special problems or those relating to public questions. It implies a completeness of scope and a thoroughness of treatment in the statement of the problem and the collection of facts, and a clear vision and keen judgment in the analysis. Applied in the public service, this grand strategy assumes a new dignity.

Dr. Durand's review of engineering progress through past generations and his look into the future make splendid material for thoughtful perusal as the basis for the advance of the profession.

The Engineering Museum as a Dynamic Influence

THE PHYSICAL comfort and the spiritual and mental well-being of our people rest in a large measure on the progress of science and the achievements of engineering. These are comparatively new forces in the development of civilization and their movements have been so rapid, their influence so far-reaching, that today we find ourselves in the midst of an era of life based on science and engineering but governed by the habits of medieval thought. If our advance is to be permanent, if our gains in well-being are to be consolidated, a great educational effort is necessary that the public may understand the methods upon which our industrial structure is based and that it may not fail to receive the inspiration that comes from such an understanding.

The engineering and industrial museum takes the place of importance in the great educational movement to make clear to the mass of people the reasons for our present state. It is an interesting commentary on American achievement that our urge to forge ahead has resulted in a neglect of the record of our achievement. We find splendid museums in Europe, but only during the last few months has American industry and engineering roused itself to consider definitely the plans for a suitable Museum of Engineering and Industry.

In this issue appears the first of a series of articles on foreign museums. Dr. von Miller, whose genius and perseverance established the Deutches Museum at Munich as a vital element in German industrial growth, relates something of his work. By displaying the development of the various branches of science and technology in a manner easily understood by all classes of people, he is successful in drawing 6000 week-day visitors and 12,000 on Sunday from a city of 600,000 inhabitants. He has proved that an engineering museum may be a dynamic influence in popular education.

Progress in Mechanical Engineering

A SPECIAL series of Reports of Progress and Prospects in Mechanical Engineering were prepared by the Professional Divisions of the A.S.M.E., printed in December MECHANICAL ENGINEERING, and presented during the recent A.S.M.E. Annual Meeting. The preparation and presentation of these reports will hereafter be a regular procedure by the Professional Divisions, and a method is being worked out to make sure that the reports are accurate and complete.

From the experience gained in the presentation of these summaries at the last meeting, it is sure that the Reports of Progress and Prospects for each year will furnish an extremely valuable tool for the development and administration of an annual technical program for the Society. In addition, the collected statements provide the means for mechanical engineers who are confined narrowly to a specialty to become informed of trends of development in other branches and to utilize the advances in other fields.

Each of the reports was presented in brief form with lantern slides to show the spectacular advances. As they were presented consecutively, the session provided an interesting résumé of the year's work. Next year the time for presentation will be extended to permit discussion and questions.

Better A.S.M.E. Meetings

THE A.S.M.E. Annual Meeting is the great annual clearing house of information and inspiration for the mechanical-engineering profession, and the recent meeting was an unqualified success. During the past five years the Committee on Meetings and Program has been experimenting with various kinds and combinations of technical sessions, social events, and excursions that will satisfy the ideals for this meeting which the Committee has in mind. The program for the Annual Meeting should include papers on the newest thought and latest development of the year. It should offer the maximum opportunity for the individual member to discuss the papers and in other ways participate in the technical work of the Society. The Committee appreciates the tremendous importance that a meeting offers for the development of professional comradeship, and the program of social and entertainment events and excursions is planned with that in mind.

For the last Annual Meeting the program included the new Henry Robinson Towne and Robert Henry Thurston Lectures and a list of splendid technical papers. The papers were printed well in advance of the meeting, and were available to all who desired them for the preparation of discussion. The social events included the

Dinner with its splendid atmosphere of Society fellowship, and other interesting events both for ladies and men. While the success of the meeting was a cause of great gratification to the Committee, there must nevertheless be opportunities for further improvement.

An obvious opportunity lies in the need for reducing the number of simultaneous technical sessions. The problem involved is one of balancing a diversity of program against strength and interest. It is highly important that a diversified program be provided as the scope of the Society is broad, and since the Annual Meeting is the great clearing house for all the members of the Society, it seems desirable to provide them with the opportunity to secure the maximum benefit from it through papers that are presented and discussed, and through the opportunity for participating in the discussion and in the making of friends. A simplification of the technical program, if it can be achieved without affecting its strength and diversity, will improve the Annual Meeting decidedly, and the Committee is working along that line.

Industrial Heat and Power

THE Annual Meeting papers on industrial furnaces and industrial power were read with avidity and discussed with spirit. As these sessions were in the nature of a new departure in A.S.M.E. programs, their success was very encouraging to the Professional Divisions on Fuels and Power, under whose auspices they were planned and conducted.

The session on furnaces was interesting as it brought out important matters about which new information is needed. These may be the topics of papers at future sessions. One interesting trend that came out in discussion was the striving after a measure of furnace efficiency because of the need for quality of furnace output instead of quantity. The term "dollar-efficiency" was coined for the occasion to indicate a ratio of dollar input of fuel, labor, etc. to dollar value of output.

The session on industrial power brought out discussion from power engineers in many industries and, as in the furnace session, most of it concurred with the papers. The power papers dealt mainly with problems in the large industrial plant and the impression from the papers and the discussion was that an aggressive group of engineering thinkers are at work on the problems of industrial power. A second impression was the obvious need for more data, for complete data, and for data that will permit intelligent comparison between engineers in separate plants. The industrial-power group in the Society will work out naturally and easily the best way to get the data on a comparative basis.

The Constitution of Coal

MORE study of the constitution of coal to increase the money-saving possibilities in the every-day problem of fuels and combustion was urged by H. W. Brooks, secretary of the Fuels Division, in a recent letter to the members of the Division. He pointed to the large volume of coal by-products that are being burned inefficiently and stressed the need for more general understanding of the nature, value, and economic recoverability of coal by-products. The following is quoted from his letter:

It is a general misapprehension that proximate and ultimate coal analyses reveal the constitution of coal. Franz Fischer, famous German scientist, says in this connection that while proximate and ultimate analyses are important both from the scientific and technical point of view, they tell the chemist no more concerning the number and kinds of chemical compounds that constitute coal than the reader would learn of the contents of a book if told that the printed contents consisted of 15 per cent of the letter "e," 5 per cent of the letter "n," 1 per cent of the letter "g," 4 per cent of the letter "b," etc. As the reader must have the grouping of letters into words and words into sentences, so the chemist must have the grouping of atoms into molecules and the proportion of each molecular compound in the coal aggregate before he acquires an adequate knowledge of the constitution of coal. Many mechanical engineers consider this exclusively the field of the chemist, the research man, or the university professor, little realizing that the crying need of economic by-product recovery is correct mechanical engineering.

The processes of power generation from coal are on the verge of a change and the mechanical engineer should stimulate and guide the researches in the use of coal because his experience will govern the design and operation of new installations.

Industrial Self-Government

THE obsolescence of the legislative method for the solution of the specialized technical problems of industry and business is emphasized in an article in the December *Nation's Business* by Dr. P. G. Agnew, secretary of the American Engineering Standards Committee.

The rapidly increasing flood of legislation is a matter of national concern. New laws are enacted at the rate of 15,000 a year, and with the increasing influence of science and engineering upon the comforts and well-being of man these laws are of an increasingly technical character. They exceed the bounds for possibilities of enforcement and of public understanding and approval. This is pointed out by Dr. Agnew, who suggests that the development of non-legislative methods for such problems through coöperative channels offers a ready solution.

By setting up national standards of production of materials and methods, industries may forestall the necessity of dealing with industrial problems by legislature, court, or commission. In the realm of standardization, industrial self-government has reached its highest development through coöperation rather than through legality. As an example of the standardization plan, Dr. Agnew relates the method of obtaining a national consensus of the reasonable provisions for protection of workmen in the use of grinding wheels under the procedure of the American Engineering Standards Committee. Comparing this method with the legislative, Dr. Agnew proceeds:

The reaching of a national consensus on such an industrial problem, through the statutory-law process, is an extremely difficult matter. In the legislative mill most specialized problems get lost in the game of partisan politics over popular issues. In nearly all cases the overwhelming majority of people are necessarily ignorant both of the existence of the problem and of the attempted legislative solution.

The legislative method, in short, is not a suitable one for the solution of innumerable specialized and more or less technical problems that arise in the development of industry and business. It does not reflect upon either the ability or the probity of legislators as such, any more than the statement that hammer, chisel, and saw are not suitable tools for the making of watches reflects upon either the ability or probity of carpenters as a class.

The more important phases of the standardization movement have, however, to do with specifications as a basis of purchase, methods of test, nomenclature, and dimensional standardization to secure interchangeability of supplies and to further mass production.

Loose phrases in describing products, such as, "all materials shall be of best commercial quality," and "good workmanship shall be required throughout," which are even yet frequently used in contracts, are but invitations to the law courts. In a wide range of products such loose phrases are giving place to definite, clear-cut specifications which may be interpreted in the acceptance or rejection of material without danger of misunderstanding by any competent engineer or testing laboratory.

The same type of work is being done on an extensive scale in regard to mechanical dimensions in order to insure the proper fitting of parts and the interchangeability of supplies.

From time to time suggestions are made in all industrial countries that such technical matters as these be made subject of legal enactment and enforcement. Fortunately such efforts have met with small success, and nearly every one familiar with the subject feels that such questions should be left to industry to work out by some such democratic method as the one which has been outlined.

Standardization carried out on a national inter-industry basis is a recent development. Yet such a stage has now been reached in all of the important industrial countries. Of the nineteen national standardizing bodies now in existence, all but one have been organized during or since the war. Each of these serves as a clearing house and provides the machinery for systematic coöperation of all interested groups within its own country.

More than 250 national organizations are officially coöperating in the work of the American body, the American Engineering Standards Committee. These are primarily technical and trade associations, and departments and bureaus of the Federal Government. In five years of active work seventy national standards have been formally agreed upon and a hundred others are under way. Each project is in the hands of a joint committee made up of representatives of all interested groups. Usually ten to fifteen national organizations are represented on a project, but sometimes there are as many as thirty-five.

In a very real sense each of these joint committees is a miniature industrial legislature, organized upon an industrial rather than upon a political or geographical basis, and engaged in the development of a standard or "code" for the guidance of industry.

The whole movement is based upon the principle that purely industrial standards should not be subject to legislative or other legal control, or to governmental pressure of any kind, but that they should be developed and applied through voluntary, systematic coöperation of the industries themselves, though always with the full coöperation of any and all governmental agencies concerned, but on precisely the same basis as that of any other interested group.

A Platform for Engineering Foundation—An Announcement

ENGINEERING advances by continual gain and diffusion of new knowledge. Organizing for effective conduct of research under the auspices of the four national American Societies of Civil, Mining and Metallurgical, Mechanical, and Electrical Engineers, has, however, not been a simple task. Nevertheless, important progress has been made recently.

Technical investigations have been conducted by these societies severally for years, but there has been little correlation and no comprehensive program. Only within a decade have engineers come to understand research in the same sense as scientists. Ambrose Swasey, by his far-sighted suggestion in 1914 of an engineering-research foundation, and a gift for the beginning of its endowment, compelled study of this problem.

Then came the Great War and the organizing of scientists and technologists to aid the Government should our country become involved, as in 1916 appeared inevitable. The Engineering Foundation assisted, therefore, in establishing the National Research Council and coöperated with it through the war and reconstruction. Indeed, it has been said repeatedly that if the Foundation had accomplished nothing else, this service alone would have justified Mr. Swasey's gift. Scientists and engineers repeatedly gave practical demonstration of the usefulness of research in meeting war emergencies. In peace, also, wisely directed coöperative research can be useful, for it can aid in solving urgent problems, and, besides, add to the store of knowledge on which are based progress in industry, advancement of engineering practice, and improvement of technical education, for the greater satisfaction of human needs and desires.

In 1923, the Engineering Foundation again found itself facing its primary problem, but with experience accumulated and useful work done. Its Founder Societies in the interval had progressed in research and in development of their organizations and their joint relations. Together they attacked again this problem so important to the profession and the country. Naturally there has been variety in conception of the form and functions of the Foundation, and of the relations between it and the societies. Out of prolonged consideration a plan has emerged which assures progress and achievement. Its fundamentals are embodied in the Platform for Engineering Foundation given below, which was adopted at a meeting of its Board on December 10, after approval of a draft by the governing body of each Founder Society, based on a unanimous recommendation of their joint conference committee, composed of their presidents and secretaries.

A PLATFORM FOR ENGINEERING FOUNDATION

Desiring to promote active and wisely directed research as a means to scientific and technical progress and believing that systematic coöperation by Engineering Foundation and the several Founder Societies is essential to any development of the research work of the societies commensurate with the dignity, influence and resources of the profession, Engineering Foundation, while reserving entire liberty of action under the authority conferred upon it by the Founder Societies, through the United Engineering Society, adopts the following declaration of its present plan and policy:

1 Engineering Foundation regards engineering research as the preferred field for its activities.

2 It will select or approve specific researches which it will assist by appropriation of funds or otherwise.

3 It will select for each project the agency, collective or individual, which it deems most effective.

4 It will assume no direct responsibility for the prosecution of any specific research.

5 It will coöperate with the national Engineering Societies and preferably support researches approved by it sponsored by one or more of them.

6 A member of Engineering Foundation, or of its staff, may be an advisory, but not an active, member of any committee or other organization in immediate charge of a research assisted financially by the Foundation. This provision will not be retroactive.

7 Engineering Foundation reserves the right to require from committees or other organizations or individuals assisted, satisfactory progress reports as a condition of continued support.

8 Engineering Foundation will coöperate with the several Founder or other national Engineering Societies in raising funds for the prosecution of approved researches.

9 It will endeavor to prevent conflict or overlap of research effort among the agencies which it supports or assists.

10 It will coöperate in securing information of the state of the art for use of committees of the Founder Societies or other agencies.

Adoption of this plan has placed the impartial and judicial attitude of Engineering Foundation beyond the questions which, without it, inevitably would have arisen when the Foundation in future determined the allotment and use of large sums.

Under the policy adopted, researches conducted by the Founder Societies will be doubly safeguarded in their selection, since they will have passed independent approval by the board of a Founder Society and by Engineering Foundation. Likewise, collective wisdom will be exercised in the use of funds intrusted to Engineering Foundation and to the Founder Societies.

A project having been thus endorsed, members of the Founder Society advocating it should be effective, directly or through Engineering Foundation, in raising funds or securing other aid by appeal to those who may expect to benefit.

And the time may not be far distant when the intelligence of those who have benefited from engineering will perceive the advantage to be derived for the profession, for industry, and for the public from providing Engineering Foundation so adequately with funds that the effort and time now expended in solicitation, with all the incidental annoyances and waste, may be conserved for the earlier attainment of benefits sought.

L. B. STILLWELL, *Chairman*,
ALFRED D. FLINN, *Director*,
Engineering Foundation.

Unethical Use of Manufacturers' Drawings

MANUFACTURERS are confronted more and more with the problem of purchasers' demands for detail working drawings; not only in cases of contracts awarded but with preliminary bids is their inclusion stipulated—usually, so purchasing agents claim, on the insistence of the engineers.

Builders cannot and do not object to furnishing drawings necessary for the care and operation of their machinery. But demands for full sets of detail drawings, perhaps from the very nature of the request, invite, and in fact have led to, grave abuses.

While simpler parts may be readily duplicated, many machines have important features requiring special material or treatment only safely supplied by the original builder or one equally "skilled in the art." Herein lies the danger of drawings falling into the possession of less-experienced shops whose faulty construction, guided perhaps by inaccurately copied drawings, is detrimental both to the efficiency of the machine and the reputation of its original projector. Failure to recognize this has resulted in costly experiments and a belated knowledge that even the owner's interests can be served by the responsible builder better than by any less-concerned substitute. Drawings are copied in spite of injunctions to the contrary or even formal copyrights. They have been appropriated by the purchaser's employees and made public property. Engineers have been known to take drawings of several manufacturers to make a composite, and thereby acquire unfairly and without cost the results of years of high-priced work. Even our Government insists on drawings, which are subsequently used in advertising for bids on repair parts.

An important part of a manufacturer's assets is his accumulated engineering experience, which may cover years of time and millions of money. This is embodied in the machinery supplied the purchaser, who thus obtains the full benefit of it, but this does not justify his demanding that which, when divulged, robs the manufacturer of what may be his most important asset. Therefore, if he be responsible, is it an ethical proceeding for the engineer to be a party to this "pirating" of designs, especially when broadcast for the benefit of those who have borne no part of the cost of their development?

Furthermore, an economic waste ensues which has to be absorbed. Regularly furnishing engineering without any compensation whatever would compel the manufacturer's ultimate retirement from business. Any waste in engineering expense and industry suffers is visited sooner or later on those responsible for it. The purchasing agent who, in obedience to the behest of his engineer, stipulates any course that leads to an unwarranted expense, sooner or later adds to the cost of the commodity undergoing negotiation. The unsuccessful bidder must increase his

overhead to compensate for any waste incurred, and apply this increase to his future bids or retire a bankrupt.

To repeat, investigation has proven that engineers are principally responsible for establishing the abuse, and an appeal is made to the profession to eliminate the practice, if for no other than purely ethical reasons. The American Society of Mechanical Engineers' Code of Ethics for Engineers provides the remedy if it be properly interpreted. Can violators of its tenets be safely called to account? If the Code means anything potent for good, here is one situation that merits a painstaking, not superficial, analysis that will work toward the elevation of professional conduct.

As ethical understanding, permeating more or less all professions these days, grows with the attention paid it, can the engineer escape the above considerations? Already in the trade press[1] both manufacturer and buyer have been interrogated on this "abuse" and invited to a public discussion of it. MECHANICAL ENGINEERING and the *A.S.M.E. News* are better vehicles for comment proving or refuting the charge against the engineering profession, represented so largely in the Society, and their columns are open for discussion. What shall we do about it?

W. W. NICHOLS.[2]

An Appeal to Aid Bill for Providing Adequate Salaries for Federal Judges

BY EDWIN J. PRINDLE,[3] NEW YORK, N. Y.

AMERICANS having to do with engineering, science, or the industries are pretty generally aware of the tremendous importance of keeping our patent system operating in a helpful and efficient manner. They realize that that system has been of primary importance in enabling our country to attain the foremost position among the nations in inventing, manufacturing, and agriculture. When the Patent Office was going to pieces for lack of salaries sufficient to induce trained Patent Office examiners to stay in the service, the technical and scientific men and the manufacturers, after a long and arduous campaign, succeeded finally in sufficiently raising the Patent Office salaries to stem the tide of resignations, with the result that the Patent Office has been saved from disintegration and has made substantial progress toward an efficient condition.

ADJUCATION OF PATENTS

But the granting of patents is only one branch of the operation of the patent system. The other branch is the adjudication of patents and their enforcement in proper cases. This latter function is performed exclusively by the federal courts, and the efficient operation of those courts is of as much importance to the patent system as that of the Patent Office. The rise in the cost of living, and the depreciation of the purchasing power of the dollar have placed those in courts in a position where their efficiency is being impaired by causing many excellent judges to resign, and by disturbing that peace of mind without which the best work is not likely to be done. Many of the judges are restive and waiting to see whether relief will not be given them, feeling that they will be forced to leave the bench if the present condition continues. Distress of the judges is particularly keen in the larger cities where the cost of living is highest. Here also it is more unjust that they should be asked to work for totally inadequate salaries, because the compensation which they could receive in the private practice of law is correspondingly greater. The federal courts have jurisdiction over a wide variety of subjects—much wider than that of the courts of any of the states—so that the position is one of large responsibility and requires a high order of ability. Yet their salaries are so low that they are unable to live as befits their station and the high dignity of their office, and properly to educate their children. They may not practice law, and have practically no opportunities for earning, outside of their salaries.

These conditions are probably more important to the welfare of our patent system than to any other branch of the law, because almost without exception the federal judges, when appointed, have had no contact whatever with patent law. It takes years of education and experience in listening to arguments and in trying and deciding patent cases to make a competent patent judge under these circumstances. When a federal judge who is efficient in patent law resigns, the process of education has to be gone through with by his successor, and the result necessarily is such in these cases that the average ability which is brought to the decision of patent cases over a series of years is low. A few unwise decisions would cost not only the parties but the country many times the difference now existing between present salaries and adequate ones.

The United States district judges receive but $7500 per annum, and United States circuit judges only $8500. Comparison with the salaries paid in the state courts shows the gross unfairness of these salaries.

In New York City the Supreme Court judges receive $17,500, and the question is being considered of raising that salary. The judges of the New York Court of Appeals in Albany receive $13,750.

In New Jersey the judges of the Supreme Court receive $18,000; in Pennsylvania, $17,500; in Illinois, $15,000; in Massachusetts, $12,000 and in Michigan, $10,000.

A bill having the approval of the federal judges has been introduced into Congress, known as the Reed Bill, which provides salaries for the circuit judges of $15,000 for the Second Circuit, comprising New York and Vermont; $14,000 for the next most populous circuits—the Third, Seventh, Eighth and Ninth; and $13,000 for the remaining of the nine circuits.

The bill provides salaries for the United States district judges of $10,000, with the provision that if the population in a district exceeds 2,000,000 the salaries shall be increased $500 for each 100,000 population in excess of that sum up to within $1000 of the circuit judges' salary. If the differential in favor of the salaries in the more populous districts should not be enacted, then the salaries for the district judges in general should be correspondingly raised.

While our federal judicial system is one of the three great branches of our Government and is coequal in importance with the legislature and the executive, yet its cost is truly insignificant. There are only 191 federal judges, and the cost per capita is now but one and one-half cents.

No matter how conscientious a judge may be, it is impossible for him to have as high an average of clear, penetrating thought in deciding the many intricate and important questions which come before him if his living and that of his family are inadequately provided for, as he could were his mind reasonably free from financial care. The loss to the public which comes through making avoidable mistakes or failure to think clearly through a problem under these conditions must be vastly greater than the cost of proper salaries.

As Ex-Judge Edwin L. Garvin of Brooklyn has said: "The present salaries paid to United States judges are a disgrace to the American people." Judge Garvin has just left the federal bench, being forced to do so by inability to live on his salary and the absolute impossibility of giving a college education to either of his children. Many of the federal judges are eking out their salaries by using the savings which they have provided for their old age. The American Engineering Council has adopted vigorous resolutions favoring the increase of the federal judiciary salaries, and last winter appeared by Mr. L. W. Wallace, its Executive Secretary, the Chairman of its Patents Committee, and other representatives before the committees of Congress in favor of bills for that purpose. These efforts will be continued and reinforced at the present session of Congress.

Fair play and simple justice should make every American citizen interested in correcting this unjust and unwise condition. Every man and concern who is at all interested in patents and in the preservation of our patent system in an efficient condition should express themselves to their senator and representatives as being strongly in favor of immediately passing the Reed Bill or, if not that bill, some other bill for raising the salaries at least as high as that bill.

Let us be as effective in aiding the federal judges as we were in aiding the Patent Office. That can be done if every man will do his duty.

[1] See editorial in the *American Machinist*, Sept. 17, 1925, p. 488.

[2] Assistant to President, Allis-Chalmers Mfg. Co., New York, N. Y. Mem. A.S.M.E.

[3] Chairman Patents Committee of American Engineering Council.

John A. Stevens Appointed as Honorary Chairman of A.S.M.E. Boiler Code Committee

Underwood & Underwood

JOHN A. STEVENS

AFTER fourteen years of service as Chairman of the A.S.M.E. Boiler Code Committee, John A. Stevens has resigned from this important and responsible post in the field of boiler standardization in the feeling that he deserves a rest from his arduous duties and hoping to transfer the responsibility to a younger and more active individual. To celebrate the remarkable effort which has been displayed by him in this self-sacrificing and almost superhuman work, the Council of The American Society of Mechanical Engineers has conferred a fitting honor upon Mr. Stevens by appointing him as Honorary Chairman of the Boiler Code Committee. This honor was bestowed upon Mr. Stevens at a meeting of the Council on November 30, 1925, the tribute to his interest and devotion being conveyed in the form of the testimonial illustrated herewith.

The public-spirited character of Mr. Stevens' remarkable work in the chairmanship of the Boiler Code Committee merits a brief study of his life and experience. Mr. Stevens is a remarkable example of the self-educated engineer, being one of those whose personal ability has pushed him to the top of his profession without the assistance of a technical education. His success has, however, influenced him to devote his life to the service of others and for the good of mankind.

Born at Galva, Illinois, in 1868, Mr. Stevens received a grade-school education and was later graduated from the Saginaw, Mich., high school. Following this he attended the University of Michigan for one year, and then left to serve a three-year apprenticeship as a machinist in the shop of Mitts & Merrill, of Saginaw; he also worked for about a year as assistant toolmaker with the Pere Marquette Railroad.

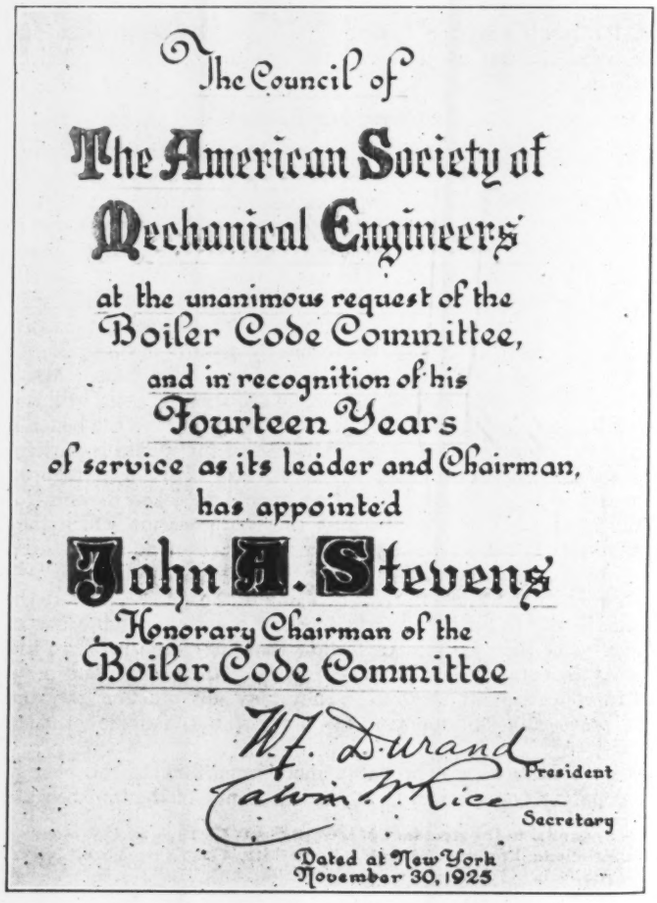
Mr. Stevens' experience as a steam engineer began when he turned his attention to marine service on the Great Lakes. He served as engineer on a number of lake steamers, and in 1893 he came East and entered the ocean steamship service in the employ of the International Navigation Co. of New York. He served on a number of this company's liners and received rapid promotion until in less than three years he was first assistant engineer of the *St. Paul*. While in this service he obtained an unlimited engineer's license for ocean steamships—the highest-class license issued—at the age of 27 years.

In 1896 he left marine work and became chief engineer of the Merrimack Manufacturing Co., of Lowell, Mass. During the thirteen years he spent in this position, Mr. Stevens practically rebuilt the entire steam plant at Lowell and at the same time superintended the power departments in the company's southern mills.

He resigned his position with the Merrimack Company in 1909 and spent three months in Europe, gathering special information on steam boilers, steam turbines, and condensers. On his return from Europe he opened an office as general consulting engineer, specializing, however, on light, heat, and power work. In this connection he has had a wide experience in power-plant analysis and in the supervision of construction work. Mr. Stevens has also done some original work in the line of invention, having eight patents containing 113 claims on water-tube boilers as well as on the American steam superheater. He is also co-inventor of the Stevens-Pratt boiler, which is especially designed for large central-station service.

Mr. Stevens' first contact with boiler standardization came with the organization of the Board that formulated the original boiler code in Massachusetts. He was a member of the original Massachusetts Board of Boiler Rules, representing the "boiler-using" interests. This board was created as a result of the efforts of Joseph H. McNeil, chief of the Massachusetts Boiler Inspection Department. The first meeting was held in the State House at Boston on July 5, 1907. At this meeting Mr. McNeil, who was chairman, outlined the plan to formulate a standard for boiler design which should be first of all safe, and secondly, commercial. Meetings were held weekly or oftener for practically three years. Suggestions, ideas, and data were solicited and received from all known authorities, various pamphlets were issued, and finally the board published the issue of the rules of August 5, 1909. This was the last issue made by the original board, and contained all necessary information for the manufacture or inspection of stationary steam boilers in Massachusetts at that time.

In 1911, during the A.S.M.E. presidency of E. D. Meier, a prominent designer and manufacturer of steam boilers, the idea of a universal boiler code that might become standard in all parts of the country took form, and the Society appointed the A.S.M.E. Boiler Code Committee for the purpose of preparing a standard boiler code in a more complete manner than was possible with the Massachusetts State Board. Mr. Stevens was made chairman of this committee. This work was carried on along lines similar to those followed in Massachusetts in taking counsel with all possible authorities who would be interested. In addition to numerous meetings, hearings, and much correspondence, an advisory committee was appointed. This advisory committee contained engineers representing every branch of industry interested in boilers,



either as users, manufacturers, insurers, or in any other capacity. A comprehensive code was issued in 1914, and has been adopted in a number of states.

The Committee continues to function and periodically issues information and interpretations of the code in answer to inquiries from those interested. As chairman of the Committee, Mr. Stevens had put in a great deal of time and thought and was responsible in no small measure for the success of the work.

During the war he was standardization engineer of the United States Shipping Board, Emergency Fleet Corporation, and assisted in formulating its "Rules for the Inspection of Marine Machinery."

In 1918, the Association Medal was presented to Mr. Stevens by the National Association of Cotton Manufacturers for his paper on the "Evolution of the Steam Turbine in the Textile Industry." This medal was awarded to Mr. Stevens for having contributed the most to the advancement of the cotton industry during the year 1917.

Mr. Stevens was a vice-president of The American Society of Mechanical Engineers from 1918 to 1920, and is a member of many engineering societies and clubs.

The Swedish-American Line Motorship "Gripsholm"

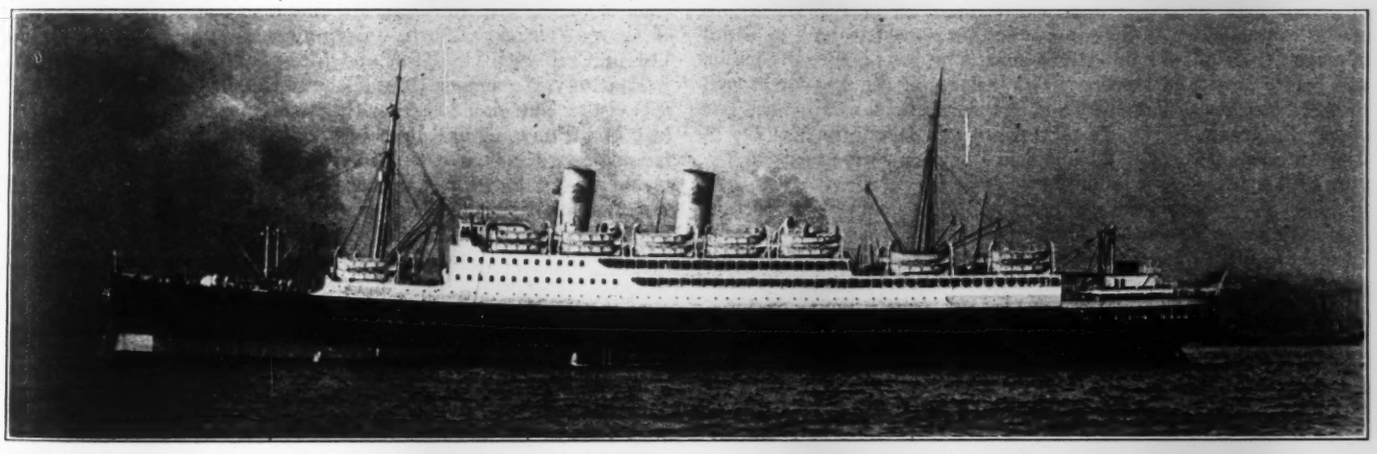
THIS 17,000-ton liner, the first motorship to be put into the North Atlantic passenger service, arrived in New York on her maiden voyage from Gothenburg, Sweden, on November 20, last. The *Gripsholm* was built at the yards of Sir W. G. Armstrong, Whitworth & Co., Newcastle-on-Tyne, England, and is 575 ft. long and 76 ft. beam. Her main engines are two double-acting units of the Burmeister & Wain type, four-stroke cycle, with cylinders 33 in. bore by 59 in. stroke. In all there are twelve cylinders, giving a total of 13,500 b.hp. at 125 r.p.m. For auxiliary engines there are six units of the same type of a total of 3600 b.hp., three of 700 hp. each coupled to air compressors, and three to 333-kw. generators.

The vessel is of interest for her passenger and crew accommodations and her remarkably low fuel consumption under practically all conditions of operation. The actual space needed for the main and auxiliary engines is less than the combined engine- and boiler-room space on a steamship. Also oil engines do not radiate heat to any inconvenient degree. These two facts taken together have not only given additional space but have made it possible to locate the passenger quarters clear across the ship on the three passenger decks in way of the engines without making some of the accommodations uncomfortably warm. The additional space afforded has been utilized for a swimming pool 30 ft. long and 15 ft. wide, and a group of special baths, electrical and vapor. The machinery is installed amidships in the hold. Forward of the main engine room is a compartment containing the auxiliary generating sets, air compressors, intercoolers, and other auxiliaries.

The name "Gripsholm" is that of an ancient castle in Sweden, and the principal public rooms of the ship have decorations and furnishings modeled on the styles and periods of the halls of the castle. It is not only the passengers, however, whose comfort has been carefully considered, but also the engineers. While no funnels are needed, in order to avoid any appearance of freakishness two dummy funnels have been installed, one being used as an elevator shaft for conveying the engineers from the engine room to the top deck, where pleasant quarters are provided for them. A service food elevator and pantry for deck officers and engineers is located in the forward funnel so that food may be served to them hot from the galley. This arrangement will eliminate the running about decks and up and down stairs in a tossing sea, of waiters carrying trays of food.

All lighting, heating, ventilating, and cooking is done by electricity, and all winches, capstans and steering gear, pumps, and auxiliaries below deck are electrically driven. The cooling of the engines is effected by water circulating in a closed circuit cooled by the flow of sea water.

One feature of the *Gripsholm* which will particularly appeal to engineers is its high economy in fuel consumption. According to estimates, while running at 17 knots the main and auxiliary engines will consume 70 tons per day at a cost of $1076, as compared with the 190 tons consumption of an equivalent main and auxiliary steam-turbine installation a cost of at $1799, making a difference of over $5500 for a single voyage between Gothenberg and New York. The total saving that will be effected in a year, allowing for the time in port, etc., is estimated at more than $150,000 for this one ship alone.



THE MOTORSHIP GRIPSHOLM

Statistical

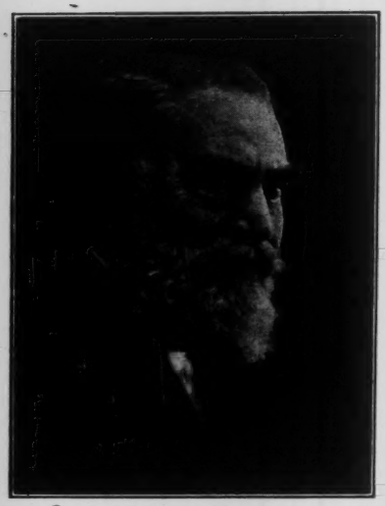
MECHANICAL ENGINEERING for 1925 contained 1190 consecutively numbered pages of text in which were printed:

216 articles and papers on engineering subjects
7 preliminary drafts of A.S.M.E. power test codes
316 abstracts of articles in other technical journals ranging from a paragraph to several pages in length
132 editorial and news notes dealing with matters of current engineering interest

together with correspondence relating to 30-odd topics, Boiler Code Committee rulings, news of various standardization activities, etc.

In addition to the 1190 text pages, which are mentioned above, 144 pages were devoted to The Engineering Index, in which items appeared referring to over 6000 articles published in the technical press of the world and relating to mechanical-engineering subjects.

Recent Visit of Dr. Oskar von Miller Was both Timely and Eventful



Oskar von Miller

THE recent visit to the United States of such an authority upon industrial museums as Dr. Oskar von Miller of Munich was most timely. Two important museum projects similar in character to the Deutsches Museum, which Dr. von Miller conceived and made a splendid reality in Germany, are just now in the embryo stage in this country. It is reasonable to say that the impetus which Dr. von Miller during his visit has given to both of these projects will be one of the deciding factors in their success.

The leaders of the projects in question, which are the Museum of the Peaceful Arts to be located in New York City, and the National Museum of Engineering and Industry to be located in Washington, made the most of their opportunity to get the advice of Dr. von Miller. At the same time this proved to be a splendid opportunity to put the importance of the projects before the public and before industrial leaders. The trustees of the first-mentioned project, which was launched and generously endowed by the late Henry Robinson Towne, Past-President and Honorary Member of The American Society of Mechanical Engineers, were hosts to Dr. von Miller while he was in New York City. He studied their problems very thoroughly and participated in a series of important conferences and meetings as described later in this account. Samuel Insull, president of the Washington project, took a similar advantage of Dr. von Miller's Chicago visit.

Dr. von Miller's itinerary was a long and unusually eventful one. He left Germany early in October, sailing direct to Mexico. There he spent some time in Mexico City in the study of the ancient Maya civilization, which is one of the subjects in which he is deeply interested.

He left for Pasadena about the last of October, where he was the guest of Dr. Robert A. Millikan, president of the California Institute of Technology. A visit to the Mount Wilson Observatory was arranged and an informal luncheon was given in Los Angeles, so altogether Dr. von Miller received at the very beginning a pleasant impression of California's hospitality.

At San Francisco Dr. von Miller was the guest of honor at a luncheon presided over by C. E. Grunsky, past-president of the American Society of Civil Engineers, and was also entertained by W. E. Creed, president of the Pacific Gas & Electric Co. In both Los Angeles and San Francisco he was given unusual opportunities to visit the important points of engineering interest.

Dr. von Miller left San Francisco on November 3 for Chicago, where he arrived on the morning of Friday, the 8th. Here as was mentioned in the introduction, he was greeted by Samuel Insull, president of the Commonwealth Edison Co. The first event of moment in Chicago was a private luncheon with Mr. Insull, Charles G. Dawes, Vice-President of the United States, and Rufus Dawes, brother of the Vice-President. This was followed on November 9 by another luncheon meeting at the Congress Hotel, at which Dr. von Miller was the guest of the engineers of Chicago. Among those present were many well-known men in various fields of engineering. W. L. Abbott, President-Elect of The American Society of Mechanical Engineers, presided at this affair.

Dr. von Miller left Chicago that night, and spent the following day at Detroit as the guest of Henry Ford. His next stop was at Niagara Falls. Here he was entertained by members of the New York State commission in charge of the parks around the Falls. He was conducted through two of the great hydroelectric plants on the Canadian side and two on the American side.

Upon his arrival at Schenectady on the evening of Thursday, November 12, Dr. von Miller was greeted by his son, who is an engineer there. He remained in Schenectady until Saturday morning, and was the guest of E. W. Rice, Jr., honorary chairman of the board of the General Electric Co., in whose plants he spent much time.

Dr. von Miller arrived in New York City on the afternoon of Saturday, November 14. He found a large and distinguished reception committee awaiting him at the Grand Central Station to conduct him to his headquarters at the Pennsylvania Hotel. From that time until he sailed on the 26th he was an extremely busy man. The first evening in New York was given to a dinner at the home of Dr. Kunz, president of the Museum of Peaceful Arts.

The following day a luncheon in Dr. von Miller's honor was given at the home of Felix M. Warburg. That night he attended a dinner at the home of Frank A. Vanderlip at Tarrytown.

The first public appearance of Dr. von Miller was on Tuesday, November 17, when a luncheon in his honor was given at the New York Chamber of Commerce. This was preceded by a visit to the Bush Terminal under the guidance of Irving T. Bush. Tuesday evening there was a reception for him at the New York Historical Society. Wednesday was taken up by a luncheon at the Faculty Club, a visit to the American Museum of Natural History as guest of Henry Fairfield Osborn, its president, and a tea at the Union League Club with Dr. Kunz and Messrs. Towne and Struthers.

Thursday, November 19, was one of the most important days of the visit. The day began with attendance with John W. Lieb at a board meeting and luncheon of the National Industrial Conference Board. That evening Dr. and Mrs. von Miller were guests of honor at the annual banquet of the Chamber of Commerce at the Waldorf-Astoria. They were seated on the dais with the group including President Calvin Coolidge.

On Friday, Dr. von Miller went to Washington for the week end. He was much pleased with the museums there and said that in them the United States had substantial beginnings for the technical museum. The German Ambassador arranged a dinner for Dr. von Miller, and at this William Howard Taft, Chief Justice of the Supreme Court of the United States, was a guest.

On Monday morning, November 23, Dr. von Miller had luncheon with Thomas A. Edison at the home of this famous inventor. On Monday evening he attended a dinner at the Engineers' Club in New York as the guest of the Council, and of Honorary Members and Past-Presidents of The American Society of Mechanical Engineers. This was followed by a joint meeting of the Founder Societies in the Auditorium of the Engineering Societies Building, at which Dr. von Miller delivered a lecture upon the Deutsches Museum in Munich.

Dr. von Miller was the founder of this great German institution and is its director, so his lecture was particularly authoritative and interesting. His article in this issue of Mechanical Engineering comprises the major portion of his lecture.

Dr. von Miller's last public appearance before sailing was at a luncheon meeting of the Merchant's Association at the Hotel Roosevelt on Tuesday, November 24. At this meeting he gave an address along similar lines to that of Monday evening. On Wednesday Dr. von Miller gave a farewell luncheon at the Hotel Pennsylvania to those with whom he had been closely associated during his visit to New York. He sailed at 10:00 a.m., Thursday, November 26, on the *Albert Ballin*.

In the final review of Dr. von Miller's visit it is apparent that he came into intimate contact with a remarkable number of prominent people in a comparatively short space of time. Among these were the President, the Vice-President, and the Chief Justice of the Supreme Court. He in turn, through his pleasing personality and profound knowledge, developed among the leaders of industry an unmistakable enthusiasm in the project for a national museum which shall have both technical and cultural value.

The President's Aircraft Inquiry

ON SEPTEMBER 12, 1925, President Coolidge appointed a board to make a study of the best means of developing and applying aircraft in national defense. This board consisted of

MAJ. GEN. JAMES G. HARBORD, retired, of New York City

REAR ADMIRAL FRANK F. FLETCHER, retired, of Washington, D. C.

DWIGHT W. MORROW, of Englewood, N. J., lawyer and banker

HOWARD E. COFFIN, of Detroit, consulting engineer and expert in aeronautics

COL. HIRAM BINGHAM, of New Haven, Conn., Senator, formerly in the Air Service and member of the Senate Committee on Military Affairs

HON. CARL VINSON, of Milledgeville, Ga., member of the House Committee on Naval Affairs

HON. JAMES S. PARKER, of Salem, N. Y., chairman of the House Committee on Interstate and Foreign Commerce

HON. ARTHUR C. DENISON, of Grand Rapids, Mich., judge of the Sixth Circuit Court of Appeals

DR. WILLIAM F. DURAND, of Stanford University, Cal., president of The American Society of Mechanical Engineers, and member of the National Advisory Committee for Aeronautics.

This body, known as the President's Aircraft Board, met in Washington on September 18 and selected Dwight W. Morrow as chairman, Arthur C. Denison as vice-chairman, and Dr. William F. Durand as secretary. Four weeks of public hearings brought out ninety-nine witnesses, including leaders of government and of industry, and over forty flying men. The final report was issued on November 30.

The report was received by the public press of the country as a well-balanced document which, in view of the conflicting nature of the testimony in matters of opinion and of fact, presented a compromise policy on which a progressive plan of American aviation may be carried out. Extracts from the report follow.

THE CONFLICT IN THE TESTIMONY

The one thing that stands out clearly at the very outset of a consideration of the problem, says the report, is the great conflict in the testimony. This conflict extends not only to matters of opinion, where it is necessarily to be expected—indeed, where to some extent it is to be desired—but also to what seem to be differences in statement of fact. There are some real conflicts on questions of fact. In most cases, however, the apparent differences in fact are merely different conclusions resulting from partial statements of fact.

AVIATION PRIOR TO THE WAR

In all this confusion of opinion one fact stands out clearly. During the past generation a great new factor has come into men's lives. Men have learned to fly. They are still subject, of course, to the laws of gravity; but they have learned to rise from the ground in heavier-than-air machines, to propel themselves above the ground, to control with skill their speed and direction, and to carry substantial weights with them. This has all happened within a little more than 20 years.

With the outbreak of the World War there was removed from aircraft development one of the great limiting factors, to wit, the question of expense. No cost was too great for anything that might contribute to the winning of the war.

THE CONTROVERSY THAT HAS GONE ON SINCE THE WAR

With the coming of the armistice, the United States began to liquidate a vast war machine, at the same time endeavoring to retain and further extend the scientific and technical knowledge which the war experience had brought. The severe liquidation brought a violent wrench to all industries, including those furnishing aircraft. Moreover, the reduced army of peace meant reduction in rank and curtailment of opportunity for all officers in the Army. It is not unnatural that the controversy which arose between the newer and the older arms of that service should have raged with some bitterness. It is impossible to attribute the controversy to any single cause, particularly in view of the fact that it has gone on in much the same terms in every country that participated in the war. The conflict is one between the old and the new, emphasized by the sharp adjustments required in a period immediately following a great war. What is needed is a more generous appreciation by each side of the difficulties of the other side. On each side there is need of patience with what seems the unreasonableness of the other side. The fundamental problem may not be settled. It may, however, be understood if men will approach it with less feeling and more intelligence.

METHOD OF APPROACH

In taking up the actual problems with which our study has been concerned, it has seemed to us useful to divide our report into two parts. In Part I we put forward a series of questions covering some matters in controversy, which, despite the conflict in testimony, admit of answers. Having answered such questions as the evidence before us requires, we then consider in Part II some positive action that we think should be taken to improve the Air Services—(*a*) with reference to the Army; (*b*) with reference to the Navy; and (*c*) with reference to industry as the source of supply for aeronautic matériel.

In suggesting remedies we rest upon the sound principle that no solution proposed at this time can be lasting. It is, therefore, of the first importance to lay the emphasis upon the best method of achieving the desired result. To that end we rely chiefly upon the appointment of an additional Assistant Secretary of War, Assistant Secretary of the Navy, and Assistant Secretary of Commerce, to devote themselves under the direction of their respective heads, primarily to aviation and jointly to coördinate so far as may be practicable the activities of their three departments with respect to aviation.

PART I

The questions to which we attempt answers are as follows:

1 *In determining an aviation policy for the United States Government, what should be the relation between the military and civilian services?*

Our answer to this question is that they should remain distinctly separate.

The historic tradition of the United States is to maintain military forces only for defense and to keep those forces subordinate to the civilian government. This policy has been amply justified by our experience.

2 *How can the civilian use of aircraft be promoted?*

A great opportunity lies before the United States. We have natural resources, industrial organizations, and long distances free from customs barriers. We may, if we will, take the lead in the world in extending civil aviation. In this field international competition is to be desired by all.

Progress in civil aviation is to be desired of and for itself. Moreover, aside from the direct benefits which such progress may be expected to bring us in our peace-time life, commercial aeronautic activity can be of real importance in its effect on national defense.

Both here and abroad, great strides have been made in the commercial use of the airplane in the last four years.

As common carriers, however, aircraft have not been used as much in this country as in Europe. In this respect they should stand on a general parity with vehicles of transportation by sea. For water-borne transport the Federal Government has provided a body of marine law. It lights the coasts, harbors, and rivers; it studies the currents and marks the channels; it surveys all navigable waters and publishes charts, sailing directions, and the Nautical Almanac; it maintains the Life Saving Service, regulates anchorages, issues weather maps and storm warnings, and spends millions yearly on river and harbor improvements; it inspects and certifies vessels for seaworthiness and examines and licenses all officers. If these aids were withdrawn water-borne transport would be difficult, if not impossible, under modern economic conditions. Unless some similar aid be given to air transport, development in that line will be seriously retarded.

The principal conditions standing in the way of progress and acting in restraint of the more rapid investment of private capital in the field of air transport are:

(*a*) The excessive burden placed upon private capital if it is to be required to pioneer in the development of flying equipment best suited to air transport and at the same time supply all the collateral requirements including airways and air-navigation facilities, especially as such facilities are, by their very nature open to the use of all, and no proprietary rights can be retained by the parties undertaking the original investment and the expense of maintenance. The parallel with maritime transport in this particular is exact.

(*b*) A fear of the hazards of the air which makes it difficult to secure passengers, and a general idea of the airplane as a military or sport vehicle, unreliable for other use.

(*c*) A general uncertainty on the part of potential operators regarding the extent of the traffic available.

(*d*) The lack of a definite legal status and of a body of basic air laws.

(*e*) The absence of Government inspection and certification of flying equipment and licensing of pilots, and the lack of control over methods of maintenance and operation in so far as they have a direct bearing on safety.

(*f*) The slowness of the development of insurance facilities.

To the end that this important field should receive the attention that it deserves, we recommend that provision be made for a Bureau of Air Navigation under an additional Assistant Secretary of Commerce. We recommend the progressive extension of the air-mail service, preferably by contract, and also that steps be taken to meet the manifest need for airways and air-navigation facilities, including an adequate weather service maintained by public authority and planned with special reference to the needs of air commerce.

Beyond these general recommendations, we do not presume to suggest the definite legislation which should be passed upon this subject. Congress has already considered it at length. The Department of Commerce has made elaborate studies. We trust that the necessary legislation and appropriations can be made effective in the very near future and a start made in this vitally important field.

3 *What should be the military air policy of the United States?*

A careful study by the Army and Navy high commands of the factors entering into the question of the air strength, should indicate the total strength needed in order to insure the proper measure of national security, while at the same time holding a consistent relation to our traditional policy of maintaining armed forces for defense rather than for aggression, and to the need of wise economy in all demands on the public purse.

4 *Is the United States in danger by air attack from any potential enemy of menacing strength?*

Our answer to this question is no.

Although there is some variance in the testimony on this point it seems to be the consensus of expert opinion that the effective radius of flight for bombing operations is at present between 200 and 300 miles.

In the foregoing we are speaking of an attack upon the continental United States, and are ignoring an attack from Mexico or Canada. To create a defense system based upon a hypothetical air attack from Canada, Mexico, or any other of our near neighbors would be wholly unreasonable. For a century we have, under treaty, left the Great Lakes unguarded by a naval force; by mutual consent the long Canadian frontier is free from armament on either side. The result has justified such a course.

5 *Should there be a department of national defense under which should be grouped all the military defensive organizations of the Government?*

The argument in favor of such a course has been and is that there is now overlapping of the Army and Navy. There is some strength in the argument.

The argument against such a course is the added complexity in organization which would inevitably result.

During a war period the President as the Commander in Chief of both services must act as the director of national defense. When the President assumes such a position the necessity of linking the defensive agencies of the Government does not stop with the Army and the Navy. The Council of National Defense, which during the World War was organized to coördinate our industries and resources, included the Secretaries of War, Navy, Interior, Agriculture, Commerce, and Labor. Railroads, coal supply, agricultural activities, important war industries, dealings with labor, all by special legislation had to be brought into coördination with the work of the Army and the Navy.

We do not recommend a Department of National Defense, either as comprising the Army and the Navy or as comprising three coordinate departments of Army, Navy, and Air. The disadvantages outweigh the advantages.

6 *Should there be formed a separate department for air, coordinate with the present Departments of War and Navy?*

Our answer is no.

Modern military and naval operations cannot be effectively conducted without such services acting as integral parts of a single command. The question left to consider is whether the country has need of a separate independent air force in addition to the air power required for use with the Army and the Navy. We do not consider that air power, as an arm of the national defense, has yet demonstrated its value—certainly not in a country situated as ours—for independent operations of such a character as to justify the organization of a separate department.

The British Air Ministry, in complete control of all of Britain's aeronautic activities, is frequently cited by those who urge the organization of an air department in our Government. Because of our different geographical position we attach no weight to this precedent. In Great Britain itself there is no unanimity of expert opinion as to the ultimate value of the Air Ministry from the viewpoint of national defense.

PART II

IN this section the report considers the Army, the Navy, and the aircraft industry as a source of supply for aeronautic material. The sections devoted to the Army and Navy contain recommendations for an Assistant Secretary of War and an Assistant Secretary of the Navy to work with an assistant Secretary of Commerce, all devoting their time and efforts to aviation matters. Representation of flying men on the general staff of the Army and in the office of the Chief of Naval Operations and other policies of organization, compensation, and personnel, are also dealt with. The section dealing with the aircraft industry reads in part as follows:

THE AIRCRAFT INDUSTRY

The importance of the aircraft industry in relation to national defense is obvious. The size of the air force needed in the event of a great war will always be far beyond anything that it is economically feasible to keep up in any country in times of peace. The rapidity of the development of the art of airplane design, rendering flying equipment inferior for service use against a major power within a few years after design, prohibits the gradual manufacture and accumulation of matériel and its storage for use in any future emergency. The airplanes to equip the expanded force in case of war must therefore be built when war is actually at hand, and the speed of their manufacture is a vital factor in military effectiveness. The relative wastage of equipment in war, too, is beyond anything known in peace, and production must be kept continuously at the highest pitch in order to supply the demands of the forces in the field.

If a certain amount of business is needed to keep an essential industry in a sound condition, the amount of support that the Government must, directly or indirectly, provide decreases as the business coming from other sources is increased. Civilian operation of aircraft furnishes an obvious non-military market for equipment. The sale of small airplanes to private owners affords another market and one which may be more important as time goes on. American manufacturers should be encouraged in their efforts to develop an export trade.

It seems to us probable, however, that for some time to come the strength of the aircraft industry in the United States will depend primarily on the number of new airplanes ordered by the services. The determination of new policies will be of no avail to the manufacturers without orders for work to be done in the factories. This does not mean that the size of a government's air force should

be determined by the need of industry. On the contrary, the size of the air force must be determined solely on the basis of the large policy of national defense.

The gradual depletion of the war stock requires increase in the amount of new equipment ordered annually. In that respect the industry's situation is assured of improvement. Whatever the size of the orders placed, however, they can be made to yield the best result both for the services and for the manufacturers if there is some continuity of policy and some clear aim.

It appears impracticable to make definite plans for the size of the air force at some period 10 years or more distant, and for the amount and type of equipment to be bought each year to reach that goal. Conditions change too rapidly. It does, however, seem feasible to lay down a general policy.

It appears that it should be possible, at this stage of the development of the art, to select a given type of machine as a standard for two or three years, with the understanding that, barring some extraordinary development, no change would be made within that time. The industry would then be assured of a continuous series of orders for a standard design, while an excessive multiplication of types of equipment in service would be avoided. Those advantages seem to outweigh the small gain in performance of the individual airplane that might at times result from a willingness to put a new type into service every few months. There should be a standard rate of replacement, selected to give a complete turnover of service equipment at definite intervals, so that the number of new pursuit machines ordered, for example, might show no extreme fluctuations from year to year.

We therefore recommend:

1 The adoption of a policy of continuity in orders and of a standard rate of replacement.

2 Production orders be given only to companies which maintain design staffs of reasonable size and keep them active.

3 Proprietary rights in design be fully recognized.

4 Governmental competition with the civil industry in production activity be eliminated except in those projects impracticable of realization by the civil industry.

5 During a period of production of a type accepted as standard there be placed a succession of small orders for experimental designs to be given limited service tests, the best of these designs produced during a two- or three-year period being adopted as the next standard. Such orders, distributed among firms having design and production staffs of proven competence, should be awarded at a liberal price, high enough to cover all the overhead expense involved in the upkeep of the design and experimental departments.

6 Existing statutes covering the procurement of supplies and requiring competitive bidding be modified where necessary to allow putting the recommendations previously made into effect.

7 Governmental research in aeronautic science be actively continued and the testing facilities of the various department agencies should be made readily available to the civil industry. The functions of the National Advisory Committee for Aeronautics should be extended to cover the field of advice to inventors regarding aeronautic inventions.

CONCLUSION

In submitting this report, Mr. President, we feel constrained to say that our diverse experiences, associations, and habits of mind necessarily produced views differing at first nearly as widely as some of those expressed in the testimony heard by us. We were a unit, however, in feeling that in the discharge of the duty which you asked us to perform our conclusions would be of practical value only in so far as they commanded our own unanimous and undivided support. We do not minimize the difficulties which we have experienced in reaching such a result. To do so would be to belittle the difficulties which must still be faced by those who under your authority, are charged with the administration and execution of existing laws and of such modifications thereof as the Congress in its wisdom may enact. We have reached a unanimous conclusion because we have approached our task in a spirit of mutual accommodation and understanding. The same spirit may prove helpful both to those charged with the grave responsibility of developing the policies in regard to the use of aircraft in national defense and to those who encounter the hazards of actual operations in the air.

Secretary Hoover's Annual Report

THE Annual Report of Secretary of Commerce Herbert Hoover, which was issued on November 30, relates important steps of progress made during the year in the national program for the elimination of industrial waste to which the Department of Commerce has devoted much effort during the past five years. He also reveals the important effect of this movement on the prosperity of the country. Secretary Hoover points out that the whole program is one fundamentally to stimulate action among industries, trades, and consumers themselves. It is obviously not the function of Government to manage business, he says, but to investigate economic questions, to survey economic phenomena, and point out the remedy for economic failure or the road to progress, to inspire and assist coöperative action, and to stimulate forces to these ends—surely all these are well within the proper field of public service.

It seems worth while at all times to reiterate the fundamental purposes of this campaign, the report continues. The philosophy that underlies it has but one purpose: that is, to maintain American standards of living for both workers and farmers, and to place production on a more stable footing. The high standards of living enjoyed by the American people are the result of steadily mounting per capita productivity. There is only one way to further advance these standards, and that is by improved methods and processes, by the elimination of waste in materials and motion in our production and distribution system.

Secretary Hoover presented a condensed statement by officials in his department touching on definite fields of effort which were outlined by the Department at the beginning of the undertaking four years ago. These included

1 Elimination of waste in railway transportation by the provision of adequate facilities and better methods.

2 Vigorous improvement of our natural interior water channels for cheaper transportation of bulk commodities.

3 Enlarged electrification of the country for the saving in fuel, effort, and labor.

4 Reduction of the periodic waves of unemployment due to the booms and slumps of the "business cycle."

5 Improved statistical service as to the production, distribution, stocks, and prices of commodities, both domestic and foreign, as a contribution to the elimination of hazard in business and therefore of wasteful speculation.

6 Reduction of seasonal employment in construction and other industries, and intermittent employment in such industries as bituminous coal.

7 Reduction of waste in manufacture and distribution through the establishment of grades, standards of quality, dimensions and performance in non-style articles of commerce; through the simplification in dimensions of many articles of manufacture, and the reduction of unnecessary varieties; through more uniform business documents such as specifications, bills of lading, warehouse receipts, etc.

8 Development of scientific industrial and economic research as the foundation of genuine labor-saving devices, better processes and sounder methods.

9 Development of coöperative marketing and better terminal facilities in agricultural products in order to reduce the waste in agricultural distribution.

10 Stimulation of commercial arbitration in order to eliminate the wastes of litigation.

11 Reduction of the waste arising from industrial strife between employers and employees.

As a result of the progress made in this definite public movement to increase national efficiency, combined with notable advances in science, improvement in methods of management and prohibition and other contributing factors, the United States shows a most astonishing transformation which was epitomized in a statement from the Department of Labor to the effect that during the five years from 1920 to 1925 wage rates increased from an index figure of 199 to 228, while the average wholesale prices of all commodities decreased from the index figure of 226 to 150 based on 100 as the 1913 figure.

The report also contains statistics showing business trends.

Book Reviews and Library Notes

THE Library is a coöperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E. and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The 1925 Aircraft Year Book—A Review of American Aeronautics

AIRCRAFT YEAR BOOK, 1925. Published by the Aeronautical Chamber of Commerce, Inc., New York. Cloth, 6 × 9 in., 316 pp., 87 illustrations. $5.25.

THE Aircraft Year Book, a publication of the Aeronautical Chamber of Commerce, gives an account of the present status of American aeronautics. It digresses from American aviation in an important chapter devoted to world aeronautics. In 1919 the Aeronautical Commission of the Versailles Conference drew up an International Convention for Air Navigation, now ratified by twenty-two important powers, and signed but never ratified by the United States. The Convention established a permanent International Commission for Aerial Navigation, which has recently held its seventh session. The Convention and the International Commission have provided a basis for flying practice in the various contracting states, by defining rules for the licensing of pilots and aircraft, the certification of airdromes, the control and signals of air traffic, and the marking of aircraft and airdromes, and have in many other ways increased the safety of flying. In every important country in Europe and in Canada an authoritative administrative body is at work granting subsidies to air-transport companies, regulating flying along the lines of the International Convention, and establishing airports, airways, and air beacons.

The Year Book presents the most striking statistics of the growth of European air transport and travel. Yet Europe offers fewer possibilities for air transport than America, because of its smaller distances, lesser concentration of industry and business, handicaps in the shape of many customs barriers, and because of lesser inclination on the part of business men to employ new methods of accelerating business if these methods are expensive. If American civil aviation has hitherto lagged behind European aeronautics, it is certainly due to lack of Government support.

But the Year Book does not ask for subsidies. It calls a short but most important chapter "Accidents—And the Lack of Air Law," and asks for air regulation, airways, and for the establishment of auxiliary services in meteorology and radio direction finding.

It summarizes the requisites for safe flying as follows:

1 A machine, sound aerodynamically and structurally
2 A reliable engine, of sufficient power
3 A competent, conservative pilot and navigator
4 Airports and emergency landing fields, sufficiently close together to insure gliding to safety
5 Nation-wide weather forecasts specialized and adapted to the needs of fliers
6 Adequate charting of air routes.

Certainly without air regulation the record of injuries in American flying is lamentable. It is particularly bad with the itinerant or "gypsy" fliers, who, without any fixed base of operation, fly from city to city, from fair to fair, and earn a precarious living in carrying passengers and in exhibitions of stunt flying. With the regular fixed-base operators there were only three fatalities for 922,048 miles of flying during the year ending Nov. 1, 1924. The "gypsy" fliers showed the unenviable record of eighty-nine accidents and seventy-five fatilities in about 1,000,000 miles of flying, or one fatality to about 13,500 miles.

Study of the accidents one by one reveals the fact that a great number of them could have been avoided by some form of inspection or licensing. The following are some of the accidents which air regulation would certainly have prevented: disasters overtaking student fliers taking their machines home *preparatory to undertaking the carriage of people and goods in interstate commerce;* three passengers riding in a two-passenger plane; home-made plane bursting apart in the air and killing the maker, his wife, and little son, etc., etc.

It is regrettable and extraordinary that the many bills introduced to regulate flying have failed to pass through Congress in spite of the fact that well-informed opinion is unanimously in favor of air regulation, as shown by Congressional hearings, by resolutions of municipalities, state legislatures, and such bodies as the American Bar Association, and by hundreds of editorials in publications of every variety of political opinion.

INDUSTRIAL AVIATION

The Year Book adopts a much brighter tone when it discusses the industrial applications of the airplane, as in aerial surveying and crop dusting.

Aerial surveying is one of the largest organized phases of commercial aviation in the United States, both in gross business and in the number of planes and men employed. Gross sales in aerial surveying have advanced from $30,000 in 1919 to half a million dollars in 1924, with a conservative estimate of over $1,000,000 for 1925. There are now well-organized corporations in this field such as the Fairchild Aerial Surveys, Hamilton Maxwell, Underwood & Underwood, etc. Aerial surveying is of great importance to the engineer. For example, the Fairchild company is now offering commercially a system of making line maps, which consists of taking aerial photographs in the usual manner and furnishing a complete set of these prints to the engineers; the latter take the photographs into the field, and by using them as plane-table sheets determine by stadia survey the proper elevation on the ground, and sketch in the contours on the uncorrected aerial photographs. Photographs with the contours inked in are returned to the laboratories where by a process known as "radial control" the maps are completed, all corrections for scale being made in the process of tracing. In one instance in the Northwest where a number of hydroelectric developments were planned and storage reservoirs necessary, the entire survey was made by this method. A development of aerial maps which has come to the front in the last year is their utilization in tax appraisal. In one case the state appraisal of certain properties was raised from $58,000,000 to $98,500,000 at a cost of only $22,000 and not a single case of increase in value was carried to the courts. The use of aerial photography is also extending in timber cruising, in the geological survey, and in many other fields.

Another industrial use of the airplane is in cotton dusting. Nearly 400,000,000 acres of cotton are infested with the boll weevil and the pest is gradually increasing its operations. The cotton planters are said to be losing $200,000,000 a year in this war with the weevil. Coöperation between the Bureau of Entomology, private airplane constructors, and the War Department has resulted in a very successful technic of dusting with calcium arsenate from planes equipped with special dusting tanks, with air under pressure providing a fine spray, and with dust from the hopper caught in the propeller blast distributed over a path two hundred feet wide.

A mule-drawn, negro-operated ground machine covers 30 acres in one night. One airplane can dust from 200 to 1000 acres in an hour, with extraordinary improvement in effectiveness and saving in cost.

The Year Book lists many other curious and useful services that the airplane is now rendering.

AIR TRANSPORTATION

The ever-growing achievements of the Air Mail with its successful establishment of night flying are described in detail. The achievements of the Air Mail have already been dealt with in the columns of MECHANICAL ENGINEERING. What is more significant at the moment is the formation of solid transportation companies organized to secure the contracts for carrying air mail which the Postmaster General is authorized to place under the provisions of the Kelly Bill. The Ford Airline, the National Air Transport Corporation with a subscribed capital of $200,000, and the Eastern Airways are companies which number as their directors men of wealth and vision who are prepared to risk their capital in aviation purely as an experiment of national interest. The Year Book does not yet list the contracts granted for the carrying of Air Mail. These are to date: Boston to New York via Hartford; Chicago to St. Louis via Springfield; Chicago to Dallas and Fort Worth; Salt Lake City to Los Angeles; Elko to Pasco; and Seattle to Los Angeles. The Air Mail system is becoming transformed from a line into a wide belt.

TECHNICAL PROGRESS

The Year Book is quite right in regarding commercial developments coupled with the various governmental investigations, as indicative of a national awakening to the value of commercial aviation. Technical progress is keeping fully abreast or even well ahead of industrial developments. Only a few items illustrating progress need be mentioned. The DH-4 war planes rebuilt by the Air Mail carry a pay load of only 500 lb. in spite of their powerful Liberty motors. The new mail planes ordered by the Post Office Department, such as the Curtiss Carrier Pigeon, fly faster, land more slowly, and carry pay loads of well over 1000 lb. with the same Liberty motor. The Stout Air Pullman, now manufactured by the Ford Motor Car Co., is an example of all-metal construction in duralumin which is unsurpassed by anything abroad. The arrival of the *Los Angeles* in the United States and the transfer of the engineering staff of the Zeppelin Co., to the Goodyear-Zeppelin Co. at Akron, Ohio, have shifted the center of rigid-airship development from Europe to America. In the design of aero engines the supremacy undoubtedly rests with the United States. Nothing in the world approaches the Curtiss V-1400 engine, which develops 500 hp. at 2000 r.p.m. and which weighs only 670 lb. It is significant that an English constructor is purchasing the Curtiss D-12 (from which the V-1400 was developed) in quantities. In aeronautical instruments the development of the earth inductor compass by the Pioneer Instrument Company has eliminated many of the hazards of long-distance navigation. Most effective beacons and landing lights are being developed with rapidity. Altogether the section of the Year Book devoted to technical progress is encouraging evidence that American commercial aviation is now overcoming the handicap of Congressional neglect.

Theory of Plates

DIE ELASTISCHE PLATTEN. By Dr. Ing. A. Nadai. Julius Springer, Berlin, 1925. Boards, 6 × 9 in., 326 pp., 187 illustrations and 8 tables, 24 marks.

THIS book has been written by a very well-known authority on the theory of plates, contains the theory of bending of plates and slabs, and has many numerical tables and graphs which will undoubtedly be very useful in actual design as a means of figuring stresses and deflections in plates under different types of loading and with different boundary conditions.

The first chapter of the book presents the general theory of bending of thin plates under normal loading. In this chapter the differential equation for the deflected surface is established and the boundary conditions are discussed in detail.

In the second chapter the author deals with several particular cases of bending of plates, the cases of rectangular and circular plates being discussed in detail. The cases of plates resting on many supports and plates strengthened by ribs are also discussed.

Chapter III is devoted to the application of equations of finite differences to the approximate solution of the problem on bending of plates.

In Chapter IV the two-dimensional problem of elasticity is discussed and the fundamental equation for the stress function established.

In Chapter V the problems on buckling of plates under compressive and shearing forces are dealt with, and the necessary numerical data for figuring the critical values of forces are given. A lengthy discussion is given of the important cases of rectangular and circular plates.

In the last two chapters the problems on large deflections of plates and on the stress distribution at the points of application of the loads are considered. In conclusion a bibliography of the subject is given.

In many places the book presents new developments in the theory of plates made by the author himself, and the work is the most complete treatise on the subject available. It will prove of practical interest to engineers who are occupied with the calculation of stresses in and deflections of plates and slabs for metallic and reinforced-concrete structures.

S. TIMOSHENKO.[1]

East Pittsburgh, Pa.

Popular Research Narratives—A Second Volume

ENGINEERING FOUNDATION has just collected the second fifty of its Research Narratives and issued them in a book better bound and a little larger than Volume 1. The second volume is illustrated with five portraits of engineer-scientists. It has an introduction by Prof. M. I. Pupin, president of the American Institute of Electrical Engineers and the American Association for the Advancement of Science. The price is one dollar, postpaid. Volume 1 is still obtainable at fifty cents. These brief stories of research, invention, and discovery have been well received, widely copied, and utilized in many ways. They have carried the gospel of science coupled with the names of the American Societies of Civil, Mining and Metallurgical, Mechanical, and Electrical Engineers into most of the countries of the world. Requests and remittances should be sent to Engineering Foundation, at 29 West 39th Street, New York.

Books Received in the Library

ANALYSIS OF RAILROAD OPERATIONS. By Joseph L. White. Simmons-Boardman Publishing Co., New York, 1925. Fabrikoid, 6 × 9 in., 381 pp., tables, $4.

The aim of this book is to prepare the railroad man so that he can interpret the accounting and statistical statements of a railroad and analyze its operating results even though unfamiliar with the technical details of railway-accounting procedure.

DYNAMIK, 2; Dynamik von Körpersystemen. By Wilhelm Müller. Walter de Gruyter & Co., Berlin and Leipzig, 1925. Cloth, 4 × 6 in., 137 pp., 1.25 mk.

Devoted to the methods for mathematically investigating the motion of structures composed of rigid elements. An attempt is made to condense the development of the subject as much as possible and to arrange the whole systematically. The analytic methods used are grouped in general around d'Alembert's principle.

FOUR-FIGURE MATHEMATICAL TABLES. By G. W. C. Kaye and T. H. Laby, Longmans, Green & Co., London and New York, 1925. Paper, 6 × 10 in., 26 pp., $0.40.

A convenient collection of the mathematical functions usually tabulated in four-figure tables, printed in clear type. Logarithms, anti-logarithms, reciprocals, squares, natural and logarithmic sines, cosines and tangents, degrees to radians, powers, roots, and reciprocals are included.

[1] Engineer, Westinghouse Research Laboratory. Mem. A.S.M.E.

Forty-Sixth Annual Meeting of the A.S.M.E.

(*Continued from page 75*)

spectators and exhibitors, this exposition was far ahead of the three previous shows.

Of the 84,599 persons who visited the exposition during the week of November 30 through December 5, 16,481 registered at the desk provided for that purpose at the Grand Central Palace. The visitors included the engineers who were in New York that week to attend the annual meetings of The American Society of Mechanical Engineers and the American Society of Refrigerating Engineers, as well as many prominent executives in the industrial power field. The plan of sending out invitations for the show, which was put into effect for the first time this year, was successful in bringing to it those who were vitally interested in the exhibits.

Three floors of the Grand Central Palace were entirely filled with the exhibits of four hundred leading and representative manufacturers in the entire mechanical field. There were splendid showings of heating and ventilating apparatus, refrigerating machinery, machine tools, and power-transmission apparatus, as well as a complete representation of all types of apparatus in the power field. All of the large manufacturers of equipment for steam-electric power plants had exhibits at the show. This is a gratifying evidence that the exposition is established as permanent and national in scope.

Viewing the exposition as a whole, the outstanding characteristic seemed to be the large number of working models and full-size showings of apparatus. These comprised stack breechings, economizers, superheaters, stokers, coal pulverizers, air compressors, large motor-operated valves, and several showings of combustion-control apparatus in operation. The working models included a coal-pulverizing plant, several boilers with one side cut away and covered with glass, coal-pulverizing and conveying equipment, and coal-handling devices.

The progress made during the past twelve months as reflected by the exhibits brought together under the one roof was astounding proof of the increasing importance of the part that power generation and use play in modern industry. The achievements of the year are so numerous that in this limited space it is not possible to give them in detail, or even to point out some of the trends as indicated by the exhibits.

Technical Committee Meetings

NEVER before in the history of the Society have so many technical committee meetings been held during an Annual Meeting. They totaled twenty-five and varied in length from a luncheon meeting of one to two hours to a session carrying through the working hours of three days.

Research

The fact that interest in engineering and industrial research on the part of the Society's members is steadily increasing was again made evident at the December meeting. The recently organized Special Research Committee on Mechanical Springs held a spirited session on Wednesday morning, the Special Research Committee on the Properties of Steam and the Extension of the Steam Table held its usual annual open meeting on that same afternoon. The Special Research Committee on Lubrication also took charge of a session on this subject on Thursday afternoon. Each of these committees held meetings either before or after the public sessions.

Of the meetings held by other research committees, the luncheon meeting held by the Special Research Committee on Boiler Furnace Refractories at noon on Tuesday was probably of greatest significance. This meeting was attended by fifteen members of the committee and others vitally interested in the subject. Though the committee has not been in existence more than six months, Chairman C. F. Hirshfeld outlined a plan for the committee's activity and reported that approximately $7500 in cash had been deposited with the Society to meet the immediate needs of the committee. This money had been contributed by manufacturers and users of refractories to whom the study of this problem is vital. The Special Research Committee on Gears held a meeting on Monday at which John E. Nicholas, an engineer who has carried on the research for this committee at the Massachusetts Institute of Technology, described the results of his recent work with the Lewis testing machine designed and built by the committee and now being operated with the coöperation of the M.I.T. authorities. Wilfred Lewis presided at the meeting. The Special Research Committee on the Cutting and Forming of Metals of which James A. Hall and Prof. O. W. Boston are chairman and secretary, respectively, held its largest and most interesting meeting on Thursday afternoon. It was attended by eighteen members and guests, and began with lunch at the Engineers' Club and continued until four o'clock in the afternoon. Many prominent men in the machine-tool industry were present and took part in the discussion, which centered around the plan and scope of the committee's activities.

The A.S.M.E. Main Research Committee, of which R. J. S. Pigott is chairman, held a two-session meeting which covered more than five hours, beginning Thursday afternoon and ending Friday noon. At this meeting the committee discussed in some detail proposals for seventeen new projects.

Standardization

The A.S.M.E. Standardization Committee, of which E. C. Peck is chairman, held its semi-annual meeting on Wednesday morning to hear a report of the status of all the standardization projects for which the A.S.M.E. is sponsor or joint sponsor. Practically all of these committees, it was stated, are carrying forward their projects in a satisfactory way. A statement of progress made at the Annual Meeting on the standardization projects for which the Society is sponsor under the procedure of the American Engineering Standards Committee will be found in the Engineering and Industrial Standardization section of this issue, page 65.

Power Test Codes

The Power Test Codes group of twenty or more committees started the week with the usual quarterly meeting of its Main Committee on Monday afternoon. This meeting was attended by thirty-one men, all of whom are connected in some way with the activities of this group of 128 specialists. The most important action at this meeting was the approval by the Main Committee of the following four codes: Definitions and Values, Solid Fuels, Refrigerating Systems, and Gas Producers. Before publication as separate pamphlets these codes will be submitted to the Council for vote on approval and adoption as standard practices of the Society. Later on Monday afternoon Individual Committee No. 12 on Condensers, Water Heating and Cooling Equipment held a meeting for the purpose of discussing its new code on the Testing of Water-Cooling Equipment. Individual Committee No. 3 on Fuels also held a meeting on Monday afternoon and went through very carefully the preliminary draft of a new code on the Testing of Liquid Fuels.

Tuesday morning was the time set for the Public Hearing on the Test Code for Steam Turbines which had been prepared by Individual Committee No. 6 of which C. Harold Berry is chairman. Individual Committee No. 5 met on Tuesday morning to revise the Test Code for Reciprocating Steam Engines last published in November, 1923. The first edition of this code having been exhausted, the Main Committee at its October meeting had requested the Individual Committee to prepare a revised draft before this test code was reissued. This work was begun by correspondence and completed at the Annual Meeting.

Safety

On Thursday afternoon the Sectional Committee on a Safety Code for Machinery for Compressing Air, Harry D. Edwards, chairman, for which the Society is one of the Joint Sponsors, held a good meeting where substantial progress was made. On November 19, just prior to the Annual Meeting, the A.S.M.E. Safety Committee helped in organizing a new Sectional Committee to formulate a Safety Code for Conveyors and Conveying Machinery. J. G. Shaw was elected temporary chairman, and John A. Dickinson, temporary secretary.

The A.S.M.E. Safety Committee held its usual quarterly meeting on Thursday. This took the form of a luncheon meeting at the Engineers' Club.

THE ENGINEERING INDEX

(Registered United States, Great Britain and Canada)

THE ENGINEERING INDEX presents each month, in conveniently classified form, items descriptive of the articles appearing in the current issues of the world's engineering and scientific press of particular interest to mechanical engineers. At the end of the year the monthly installments are combined along with items dealing with civil, electrical, mining, and other branches of engineering, and published in book form, this annual volume having regularly appeared since 1906. In the preparation of the Index by the engineering staff of The American Society of Mechanical Engineers some 1200 technical publications received by the Engineering Societies Library (New York) are regularly reviewed, thus bringing the great resources of that library to the entire engineering profession.

Photoprint copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints, identify the article by quoting from the Index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication of periodical; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

ACCIDENT PREVENTION

Railway Employees. How Accidents to Employes May Be Reduced, F. C. Baluss. Ry. Rev., vol. 77, no. 17, Oct. 24, 1925, pp. 625–628. Injury by falling; handling and storing material; railway-motor-car operation; personal factor in accident. (Abstract.) Report submitted to Am. Ry. Bridge & Bldg. Assn.

AIR PUMPS

Ejector. The Ejector Air Pump, D. G. McNair. Power Engr., vol. 20, no. 235, Oct. 1925, pp. 367–370, 3 figs. Practical considerations on installation and efficient operation of steam-jet ejector air pumps.

AIRCRAFT CONSTRUCTION MATERIALS

Airship Fabrics. Fabrics Used for Gas Bags and Outside Coverings on the Schuette-Lanz Airships from 1910 to 1918 (Die Lieferung der Gaszellen und Aussenhüllen-Stoffe für die SL-Luftschiffe von 1910–1918), C. Endras. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 16, no. 15, Aug. 14, 1925, pp. 294–296. Author distinguishes between fibrous and non-fibrous materials; latter is made up only of intestinal membranes like gold-beaters' skin; former class includes cotton and silk; silk is strong but its high price, tendency to brittleness and to electrostatic charges have caused its abandonment; cotton alone remained; combination of gold-beater skin and cotton fabric led to very light and highly gas-proof material; figures for strength, weight and permissible gas leakage are given as well as shapes of gas bags, used in Schütte-Lanz ships.

Tests of Aeroplane and Other Fabrics. Engineering, vol. 120, no. 3125, Nov. 20, 1925, pp. 638–639. Review of first report of Fabrics Coördinating Research Committee of (Brit.) Dept. of Sci. & Indus. Research, on investigations of general problems giving special consideration to deterioration of fabric from various causes, waterproofing and fireproofing of fabrics, and methods of testing fabrics for strength.

AIRPLANE ENGINES

Development. Some Aspects of Aircraft-Engine Development, G. J. Mead. Soc. Automotive Engrs.—Jl., vol. 17, no. 5, Nov. 1925, pp. 496–507, 19 figs. Discusses requirements and limiting factors of dependability, size, speeds, and power-plant weight and cost, relation of thrust to weight of power plant; various engines in vogue are classified into groups according to their horsepower; advantages of air-cooled and handicaps of water-cooled engines.

AIRPLANE PROPELLERS

Air Flow Around. The Airflow Round a Body as Affecting Airscrew Performance, C. N. H. Lock, H. Bateman and H. C. H. Townend. Aeronautical Research Committee (Lond.), Reports & Memoranda, No. 956, Jan. 1925, 22 pp., 13 figs. on supp. plates. Experiments determined variation of thrust with radius by measurements of total head on three airscrews with one body, and actual velocity and direction of airstream round one airscrew and front of one body by experiments with a yawmeter; results are presented in form of streamlines and of curves of axial component velocity. Airfoil-element theory suggested which would apply to an airscrew working in front of a tractor body involves a single empirical curve representing effect of body on axial inflow at each radius; same curve is assumed to apply to screws of any design or diameter relative to that body.

The Measurement of Airflow Round an Airscrew, C. N. H. Lock and H. Bateman. Aeronautical Research Committee (Lond.), Reports & Memoranda, No. 955, Nov. 1924, 15 pp., 8 figs. on supp. plates. Describes observations made of airflow near an airscrew with standard N. P. L. type yawmeter, and deductions of values of axial, radial and circumferential components of velocity, on assumption that flow is symmetrical about axis of airscrew.

AIRPLANES

Aileron Tests. Full Scale Tests of Different Ailerons on Bristol Fighter Aeroplane, H. M. Garner and E. T. Jones. Aeronautical Research Committee (Lond.), Reports & Memoranda, No. 966, Jan. 1925, 7 pp., 10 figs. on supp. plates. Three different types of ailerons, standard F. 2B, Handley Page balanced and Bristol "Frise" were fitted in turn to a Bristol Fighter airplane; for each type flights were made with and without loads on wing tips; airplane was flown straight with no bank, engine being switched off, and measurements were made of aileron angle, rudder angle, and lateral force on control column, from which calculations were made of rolling moment, yawing moment, and hinge moment coefficients for three types of ailerons. Effect on hinge moment coefficient caused by setting ailerons up or down also discussed.

Alexander "Eaglerock." New Airplane Has a High Safety Factor and Folding Wings. Automotive Industries, vol. 53, no. 20, Nov. 12, 1925, pp. 826–827, 1 fig. Alexander Aircraft Co., Denver, Colo., produces plane, known as Eaglerock, with cruising speed of 90 m.p.h., landing speed 31 m.p.h., and safety factor of 7.7.

Beardmore-Rohrbach. "Inverness" Flying-Boat. Flight, vol. 17, no. 39, Sept. 24, 1925, pp. 617–618, 2 figs. A twin-engined monoplane flying-boat, feature of which is large dihedral angle at which wings are set; length overall 56 ft. 5 in., wing span 95 ft., wing area 791 sq. ft. See also Aeroplane, vol. 29, no. 13, Sept. 23, 1925, p. 378, 2 figs.

Bristol. Full Scale Tests of a Bristol Fighter with Increased Rudder Control, H. L. Stevens. Aeronautical Research Committee (Lond.), Reports & Memoranda, No. 972, Apr. 1925, 2 pp., 2 figs. on supp. plate. Results of investigation made to determine whether standard Bristol Fighter is under-ruddered and unsafe in hands of an inexperienced pilot who may accidentally stall near ground. A balanced rudder of 80 per cent greater area has been fitted and upper fin modified in shape and cambered to remove turning tendency due to increased height of rudder.

Flight Testing. Flight Testing at McCook Field, E. H. Barksdale. Aviation, vol. 19, nos. 20 and 21, Nov. 16 and 23, 1925, pp. 703–710 and 750–751, 7 figs. Nov. 16: Methods adopted in full-scale testing of new airplane designs. Nov. 23: Testing airplanes for full-scale research purposes.

Fokker. Non-Stalling Feature of New Fokker Plane Due to Special Wing Design, A. F. Denham. Automotive Industries, vol. 53, no. 23, Dec. 3, 1925, pp. 951–952, 1 fig. Control surfaces also contribute to stability, which is gained without use of any anti-stalling device; provision is made for one engine or three; weight, 3850 lb.; top speed, 115 m.p.h.

Gliders. Determinations of Flight Characteristics of Gliding Planes (Flugeigenschaftsbestimmungen an Segelflugzeugen), P. Raethjen. Zeit. fur Flugtechnik u. Motorluftschiffahrt, vol. 16, no. 12, June 27, 1925, pp. 235–240, 6 figs. Results obtained by observation squad in Rhön Glider Competition 1924; method of making measurements.

Handley Page. The New Handley Page Air Liner. Aviation, vol. 19, no. 20, Nov. 16, 1925, pp. 713–714, 2 figs. New 3-engined airplane for European air lines; reliability greatly increased by triple-engine principle.

The New Handley Page W.9 "Hampstead." Flight, vol. 17, no. 40, Oct. 1, 1925, pp. 625–628, 6 figs. Particulars of new biplane having three 385-hp. Armstrong-Siddeley "Jaguar" MK. IV engines; length 60 ft., span 79 ft., main planes 1563.50 sq. ft.; top speed 117 m.p.h.

Huff-Daland Bomber. The Huff Daland LBl Bomber. Aviation, vol. 19, no. 18, Nov. 2, 1925, p. 632, 2 figs. New Army Air Service bombing plane which has undergone highly successful tests; equipped with new Packard supercharged engine which develops 800 hp., it has high speed of 125 m.p.h. and can climb to altitude of 18,000 ft.

Inspection. Some Aspects of Airplane Inspection, J. J. Feeley. Soc. Automotive Engrs.—Jl., vol. 17, no. 5, Nov. 1925, pp. 441–447, 9 figs. Following description of airplane structure, author discusses structural requirements and outlines main features of properly coördinating engineering and manufacturing activities; states that no inspection is worth name or money spent on it that does not include constructive work and knowledge at all times that intentions of designers are being carried out so that safety of craft is assured; outline of inspection procedures.

Koolhoven. The Koolhoven F. K. 33. Aeroplane, vol. 29, no. 13, Sept. 23, 1925, p. 380, 3 figs. Particulars of new three-engined monoplane designed by Frederick Koolhoven and built by Nationale Vliegteug Industrie, for commercial service; engines Siddeley Pumas type, total 690 hp. and are capable of 117 m.p.h.; span 75 ft., wing area 1100 sq. ft., weight loaded 10,250 lb., wing loading 9.32 lb./sq. ft.

Lateral Controls. Full Scale Tests of a New Slot-and-Aileron Lateral Control, H. L. Stevens. Aeronautical Research Committee (Lond.), Reports & Memoranda, No. 968, Mar. 1925, 3 pp., 4 figs. on supp. plate. Describes a modified form of lateral control for air planes, designed to reduce danger of an accidental stall; discusses desirable characteristics of such a control; extracts from reports of model tests on this form of control showing that it should possess such features; summarizes flying experience obtained on an Avro 504K airplane fitted with this control.

Light. Some Light Planes at the Air Races. Aviation, vol. 19, no. 17, Oct. 26, 1925, p. 594, 3 figs. Describes three interesting light-plane designs, namely, DJI, a Henderson-engine plane; Dormoy "Bathtub;" and Roché-Dohse with new Morehouse M-80 engine.

Mercury All-Purpose. The Mercury Jr. Aviation, vol. 19, no. 19, Nov. 9, 1925, p. 682, 1 fig. All-purpose plane incorporating many of features of successful Mercury Sr. mail plane; it is single-bay biplane, with steel tubular center section supporting streamlined aluminum welded 43-gal. fuel tank.

Montee Monoplane. The Montee 4 Passenger Monoplane. Aviation, vol. 19, no. 16, Oct. 19, 1925, pp. 550–551, 2 figs. New plane is open-cockpit, side-by-side, single-control machine, of semi-cantilever type having 60 per cent of wing under rigid suspension.

OX5 Humming Bird. The OX5 Humming Bird. Aviation, vol. 19, no. 18, Nov. 2, 1925, p. 642, 2 figs. Reliable low-price commercial plane with Curtiss Ox5 engine, produced by White's Aircraft, Des Moines, Ia.; it is single-bay tractor biplane.

Pitching and Yawing Moments. Pitching and Yawing Moments with Sideslip on a Model Aeroplane with Zero Stagger, F. B. Bradfield. Aeronautical Research Committee (Lond.), Reports & Memoranda, No. 965, Jan. 1925, 14 pp., 15 figs. on supp. plates. Describes tests made on a model of an airplane with

Copyright, 1926, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

NOTE.—The abbreviations used in indexing are as follows:

Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer[s] (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

zero stagger, fairly small gap-chord ratio, and a round-section fuselage, and wind-channel tests of pitching and yawing moments with sideslip made with a view to finding any reasons why it should be difficult to bring an airplane of this type out of a spin.

Racing. The Evolution of the Modern Racing Airplane, W. L. Gilmore. Soc. Automotive Engrs.—Jl., vol. 17, no. 5, Nov. 1925, pp. 476–478 and 489. Outline of procedure adopted in designing and producing specific model of racing airplane, as well as outline of yearly progress made in development; discusses present practice in its relation to each group under headings of wings, tail surfaces, landing gear, fuselage, power plant and control system.

Seaplanes. See SEAPLANES.

Wind-Tunnel Tests. Wind Tunnel Tests of Fuselages and Windshields, E. P. Warner. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 226, Sept. 1925, 6 pp., 4 figs. on supp. plates. Results of tests made in 1918 in old 4-ft. wind tunnel at Mass. Inst. of Technology, for purpose of securing data on effect of windshield form on total resistance of fuselage of good streamline shape.

Wings. Determination and Classification of the Aerodynamic Properties of Wing Sections, M. M. Munk. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 227, Sept. 1925, 22 pp. Remarks on possible improvement of experimental determination of aerodynamic properties of wing sections; shows how errors of observation can subsequently be partially eliminated, and how computation of maxima or minima of aerodynamic characteristics can be much improved.

Preliminary Wing Model Tests in the Variable Density Wind Tunnel of the National Advisory Committee for Aeronautics, M. M. Munk. Nat. Advisory Committee for Aeronautics—Report, no. 217, 1925, 15 pp., 23 figs. Results of series of tests with 3-wing models, made to obtain general information on air forces on wing sections at high Reynolds Number and in particular to make sure that Reynolds Number is really important factor.

Wing Spar Stress Charts and Wing Truss Proportions, E. P. Warner. Nat. Advisory Committee for Aeronautics—Report, no. 214, 1925, 18 pp., 24 figs. In order to simplify calculation of beams continuous over three supports, series of charts have been calculated giving bending moments at all critical points and reactions at all supports for such members; using these charts as basis, calculations of equivalent bending moments, representing total stresses acting in two bay-wing trusses of proportions varying over wide range, have been determined, both with and without allowance for column effect.

Wright-Bellanca Monoplane. Wright-Bellanca Monoplane. Aviation, vol. 19, no. 18, Nov. 2, 1925, pp. 634–635, 2 figs. High performance on low power characterized in new plane, which seats 5 passengers comfortably; for express and mail carrying, a large cabin space of 122 cu. ft. gives good cargo room.

AIRSHIPS

Commercial and War-Time Uses. Airships and Their Uses, Both as Commercial Vessels and in Time of War, C. D. Burney. Inst. Transport—Jl., vol. 6, no. 9, July 1925, pp. 454–457 and (discussion) 457–467. From war point of view, author believes it is sound to consider airships solely from aspect of their utilization as long-distance reconnoissance vessels for use with Navy; capabilities of vessels being constructed at present time, consideration of vessels used commercially in peace time and as reconnoissance units in times of emergency.

Commercial Value. The Airship and Its Place in Commerce, H. H. Blee. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 961–972, 19 figs. General survey of development of airship and discussion of its commercial possibilities: author predicts that within a few years this type of airship, especially when using helium as lifting medium, will be classed as safe, reliable, time-saving, comfortable craft, admirably adapted to carrying heavy loads of passengers, mail and express on profitable commercial service over long non-stop flights.

Construction, Italy. The Trend of Airship Construction in Italy, U. Nobile. Flight, vol. 17, nos. 42 and 43, Oct. 15 and 22, 1925, pp. 670–674 and 693–696, 13 figs. States that progress made during last two years in Italy in construction of semi-rigid airships was of paramount importance; briefly summarized account of activities in Italy. Paper read at Third International Air Congress, Brussels, Oct. 7, 1925.

German Rigid. The History of the German Rigid Airship (Aus der Geschichte der deutschen Starrluftschiffes), Roeser. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 16, no. 13, July 14, 1925, pp. 251–272, 24 figs. Review of development; includes list of German rigid airships with dimensions, characteristics and performances; costs and time of building. Includes bibliography and report, by Müller-Breslau, on static conditions of Schütte-Lanz airships.

ALIGNMENT CHARTS

Construction and Use. Graphical Methods of Calculation, H. L. Seward. Mech. Eng., vol. 47, no. 11a, Mid-Novemoer 1925, pp. 1019–1033, 38 figs. Construction of Cartesian diagrams and alignment charts for use in rapid determination of values of unknown quantities in mathematical expressions.

Practical Nomography, R. O. Kapp. Elec. Rev., vol. 97, nos. 2498 and 2499, Oct. 9 and 16, 1925, pp. 570–572 and 604–606, 11 figs. How to make and use nomograms.

ALLOY STEELS

Special-Purpose. Steels for Special Purposes. Metal Industry (Lond.), vol. 27, no. 17, Oct. 23, 1925, pp. 391–392. Gives examples of steels made for special purposes, such as for drawing and extrusion dies, stamping and press tools, drawing mandrils, etc.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Brass. See BRASS.

Inner Structure. The Inner Structure of Alloys, W. Rosenhain. Roy. Soc. Arts—Jl., vol. 73, nos. 3803, 3804 and 3805, Oct. 9, 16 and 23, 1925, pp. 1000–1021, 1022–1037 and 1039–1052, 31 figs. Oct. 9: Discussion of atomic structure of alloys. Oct. 16: Deals with question of interaction of different kinds of atoms when they are brought together in single crystal. Oct. 23: Considers question of conduction of electricity through metals.

Tests. Comparative Slow Bend and Impact Notched Bar Tests on Some Metals, S. N. Petrenko. U. S. Bur. Standards, Technologic Papers, No. 289, June 27, 1925, pp. 315–346, 25 figs. partly on supp. plates. Describes parallel impact and slow-bend tests made by Bur. of Standards on some materials, mostly non-ferrous alloys, to determine whether a slow-bend test may be used as a substitute for an impact test or as a valuable addition to it, and to determine also its practicability; results obtained; interpretation of a slow-bend diagram. Bibliography.

ALUMINUM ALLOYS

Aging of. The Effect of Artificial Ageing upon Age-Hardened Aluminium Alloys, K. L. Meissner. Metal Industry (Lond.), vol. 27, no. 15, Oct. 9, 1925, pp. 333–338, 10 figs. Author replies to criticisms advanced by Dr. Marie Gayler in same journal, July 10, 1925, of certain statements in his article under above head in this journal, June 26, 1925. He does not dispute small aging at room temperatures of aluminum copper alloys, but such aging is of negligible practical importance; disagreement as to what is understood by age-hardening; fundamental differences in aging temperatures; Gayler's researches under different conditions; author points out that Gayler's results are inconsistent proof of age-hardening influence of $MgZn_2$.

Castings. Aircraft Castings in Aluminum Alloys, S. Daniels. Am. Foundrymen's Assn.—advance paper, no. 471, for mtg. Oct. 5–9, 1925, 22 pp., 14 figs. Air Service, U. S. A., uses regularly six alloys for casting purposes, composition and attributes of which are summarized: alloys of other composition, but of suitable foundry, physical and mechanical properties may, after granted deviation, be substituted for those enumerated; preparation of these alloys, their characteristics, and tests and methods of inspection required.

Improving Aluminium Alloy Castings. Machy. (Lond.), vol. 27, no. 679, Oct. 1, 1925, p. 7. Review of report published by Engineering Coördinating Research Board, describing experiments, by S. L. Archbutt, with object of improving soundness and mechanical properties of aluminum-alloy castings.

Castings, Permanent-Mold. Permanent Mold Aluminum Castings and Their Field of Usefulness, J. B. Chaffe, Jr. Am. Foundrymen's Assn.—advance paper, no. 478, for mtg. Oct. 5–9, 1925, 15 pp., 8 figs. Greatest difficulty encountered is that caused by crystallization shrinkage which is shrinkage in volume on freezing, and amounts to from 7 to 5 per cent of volume of molten metal; to get solid casting this shrinkage must be fed with hot metal and molds are therefore designed so that there is progressive freezing from points furthest from gates to metal in gates and sprues; venting of mold and thermal expansion must also be considered; compares sand-casting with permanent-mold method; many points of former are not applicable to latter; shows important differences between pressure die castings and permanent-mold castings. See also Am. Mach., vol. 63, no. 19, Nov. 5, 1925, pp. 743–744.

Castings, X-Ray Examination. X-Ray Examination of Aluminum-Alloy Castings for Internal Defects, Rob. J. Anderson. Am. Foundrymen's Assn.—advance paper, no. 459, for mtg. Oct. 5–9, 1925, 19 pp., 15 figs. Discusses application of X-ray examination and presents results of experimental work; advantages are stated to be: (1) inspection may be made without cutting or otherwise damaging parts; (2) dangerous flaws can be detected before parts are put in service; (3) flaws which might be uncovered in machining can be located before expensive machine work is done; (4) correlation of nature, amount, and distribution of internal defects in castings may be made with method of gating or some other factor, thus permitting use of smaller sections and lower factor of safety with simultaneous decrease in cost; apparatus and equipment for radiography and method of making exposures.

Founding. Some Notes on the Founding of Light Alloys, R. de Fleury. Am. Foundrymen's Assn.—advance paper, no. 460, for mtg. Oct. 5–9, 1925, 27 pp., 6 figs. Discusses factors influencing peculiarities encountered in founding of light aluminum alloys; factors of raw materials such as primary aluminum, aluminum scraps, alloying metals, and fluxes; effect of impurities such as iron, dissolved gases and alumina; types of furnaces for melting; properties of aluminum alloys for founding; high contraction of light alloys makes casting of these alloys entirely different as to foundry problems from cast irons.

Heat Treatment of Cast. Heat Treatment of Cast Al-Cu-Fe-Mg Alloy, S. Daniels. Forging—Stamping—Heat Treating, vol. 11, no. 10, Oct. 1925, pp. 346–352, 19 figs. Discusses heat treatment of sand-cast piston alloy; principles of heat treatment are applicable both to sand and chill-cast alloy.

AMMONIA COMPRESSORS

Cylinder Lubrication. Lubrication of Ammonia Compressor Cylinders, R. J. Nadherny. Power Plant Eng., vol. 29, no. 18, Sept. 15, 1925, pp. 964–965, 3 figs. Discussion of lubricants and lubricating methods used on modern types of open and closed ammonia compressors.

AMMUNITION

Cartridge-Tank Manufacture. Manufacturing Cartridge Tanks, R. S. Morecock. Machy. (N. Y.), vol. 32, no. 3, Nov. 1925, pp. 206–209, 14 figs. Methods and equipment employed by Navy Yard at Norfolk, Va.; operations on tank body; making inner cylinder and support block; assembling operations.

AUTOMOBILE ENGINES

Anti-Freeze Solution. Ethylene Glycol, G. O. Curme, Jr., and C. O. Young. Indus. & Eng. Chem., vol. 17, no. 11, Nov. 1925, pp. 1117–1120, 4 figs. Contribution of chemistry to automobile anti-freeze problem; combines qualities of both alcohol and glycerol, affords positive protection against freezing, is not corrosive or harmful to engine or radiator, and does not lose its effectiveness through vaporization or decomposition; it is odorless, free from solvent action or lacquer or varnish finishes, and permits efficient motor operation under all conditions.

Carburetors. See CARBURETORS.

Design for Fuel Economy. Motor Design and Fuel Economy, C. F. Kettering. Indus. & Eng. Chem., vol. 17, no. 11, Nov. 1925, pp. 1115–1116. Presents recognizable improvements in engine and car design which can be effected and considers some of simple underlying principles involved.

AUTOMOBILE FUELS

Developments and Research. Motor Fuels, J. S. S. Brame. Roy. Soc. Arts.—Jl., vol. 73, nos. 3797, 3798 and 3799, Aug. 28, Sept. 4 and 11, 1925, pp. 920–929, 930–940 and 942–954, 4 figs. Considers ways in which greatly increased demands for motor fuel have been met hitherto, and prospects of meeting still greater demands of near future by alternative or supplementary fuels; knowledge of relative merits of different components of various types of fuels, which can be applied to their improvement and production of blends which impart best characters to mixtures; light shed upon question of more efficient utilization of automobile fuels. Three Howard lectures.

Gasoline. See GASOLINE.

Petroleum. Petroleum Motor Fuel, K. G. Mackenzie. Indus. & Eng. Chem., vol. 17, no. 11, Nov. 1925, pp. 1105–1114, 6 figs. History of crude-petroleum production, both in United States and abroad; methods of increasing production; future production in United States and abroad; future cost of crude petroleum; gasoline from crude petroleum; gasoline from natural gas; consumption and conservation.

AUTOMOBILE MANUFACTURING PLANTS

Vauxhall Motors. The Works of Vauxhall Motors, Ltd. Automobile Engr., vol. 15, no. 207, Oct. 1925, pp. 341–347, 14 figs. Layout and equipment of automobile plant; methods employed.

AUTOMOBILES

British Design. Recent Developments in British Automotive Design, M. W. Bourdon. Automotive Industries, vol. 53, no. 20, Nov. 12, 1925, pp. 833–834, 5 figs. Adjustable front seats are popular; use of disappearing side windows increase; higher body side, wide seats and pyroxylin finishes are much in evidence. Observations at Olympia Show.

Charcoal Gas Producers for. The Malbay Charcoal-Gas-Engine Plant with Producer (Neue Entwicklungswege beim Sauggasgenerator). Wirtschaftsmotor vol. 7, no. 7, July 25, 1925, pp. 8–9, 2 figs. About 50 per cent thermal efficiency is calculated for this plant developed by French firm, R. Malbay; to attain which use is made of heat of producer gases themselves and heat of exhaust; hot gases are guided around retorts and preheat charcoal that is contained therein; exhaust gas is carried into producer itself.

Chevrolet, Manufacture of. Production Schedule a Factor in Auto Quality, A. Murphy. Can. Machy., vol. 33, nos. 24 and 28, and vol. 34, nos. 7 and 11, June 11, July 9 and Aug. 13, 1925, pp. 13–15 and 41, 13–17, and 15–18, 20 figs. Various phases of manufacturing activities of Oshawa plant of Gen. Motors of Canada, Ltd. June 11: Assembly of Chevrolet car. July 9: Spot and oxy-acetylene welding operations. Aug. 13: Body building and trimming. Sept. 10: Building of radiators from ribbon brass to complete radiator.

Constructional Tendencies for 1926. Constructional Tendencies for 1926. Motor Transport (Lond.), vol. 41, no. 1079, Nov. 2, 1925, pp. 548–552, 2 figs. Developments in mechanical features and bodywork evidenced by Olympia show; low loading level, four-wheel braking, lighter chassis, increase of pneumatic and air cushion tires, and smaller load units.

Crossley. A Six-Cylinder 18–50 h.p. Crossley. Autocar, vol. 55, no. 1563, Oct. 2, 1925, pp. 613–615, 9 figs. New model incorporates push-rod-operated valve gear, four-speed unit construction, four-wheel Perrot system braking, and wide range of bodies.

Headlighting. Motor-Vehicle Headlighting. U. S. Bur. Standards, Circular No. 276, Aug. 5, 1925, 28 pp., 20 figs. partly on supp. plate. Requirements for good road lighting are discussed and construction and operation of present-day types of electric head lamps explained; latest specifications for gas head lamps as approved by Soc. Automotive Engrs. are given; gas head lamps are used on trucks; methods used at Bur. of Standards for making laboratory tests on electric headlighting devices briefly described; state laws and regulations are discussed and suggested paragraphs for a state law presented. Appendix containing specifications under which tests for approval of types of devices by state officials are made. Bibliography.

Hillman. The Hillman "Fourteen." Auto-Motor Jl., vol. 30, no. 44, Oct. 29, 1925, pp. 959–961, 8 figs. Particulars of new model of Coventry car; 14-hp. engine having cylinders with bore of 72 mm. and piston travel of 120 mm.

Locomobile. The Locomobile Junior Eight. Auto-Motor Jl., vol. 30, no. 40, Oct. 1, 1925, pp. 841–843, 9 figs. A medium-powered car of high performance; four-wheel braking; eight-cylinder engine developing between 66 and 70 hp. at 3000 r.p.m.

Olympia Show, England. Review of Olympia Show. Automobile Engr., vol. 15, no. 208, Oct. 29 (extra no.), 1925. Contains following articles: Design considerations, p. 355; Show Review—Brief Summary of Trend of Design, p. 356; Critical Survey of Exhibits—Engines, pp. 357–373, 43 figs.; Clutches, p. 374, 2 figs.; Gear Boxes, pp. 375–377, 13 figs.; Rear Axles, pp. 377–379, 8 figs.; Front Axles, p. 380, 3 figs.; Brakes, pp. 381–387, 29 figs.; Steering, pp. 387–388, 1 fig.; Frames, pp. 388–389, 3 figs.; Suspension, pp. 389–391, 2 figs.; Tool and Accessories, pp. 391–394, 10 figs.

The Motor Exhibition at Olympia. Engineering, vol. 120, nos. 3119, 3120 and 3121, Oct. 9, 16 and 23, 1925, pp. 454–458, 473–477 and 504–508, 37 figs. Features of exhibition, and description of exhibits.

Shimmying. Prevention of Shimmy by Hydraulic Steering Control, J. W. White. Soc. Automotive Engrs.—Jl., vol. 17, no. 5, Nov. 1925, pp. 490–493, 7 figs. Experiments with hydraulic steering control with object of preventing or reducing shimmying and tramping were made by author, who asserts that elimination of backlash by doing away with mechanical joints and by holding front wheels as rigid as rear wheels has been amply proved by results to be long step in right direction; front and rear end differences that cause shimmying; how hydraulic steering is accomplished; main cylinder and master pump.

Star. Low Overall Height and Light Weight are Features of Star Six, D. Blanchard. Automotive Industries, vol. 53, no. 17, Oct. 22, 1925, pp. 691–693, 4 figs. Chassis is lower than Star Four, streamlining is better and "tubular backbone" is not used; rubber ball-type flexible coupling.

Streamline. The Persu Automobile (Luft-Widerstandsverminderndes Fahrzeug System Persu). Motorwagen, vol. 28, no. 22, Aug. 10, 1925, p. 484. Describes system of design which differs radically from standard design; to get wheels within streamline, rear wheels are closer together than front wheels; this makes it possible to avoid differential; engine is located midships and has horizontal cylinders, two and two opposite; crankshaft axis is longitudinal as usual; engine heads can be inspected from sides; cooling air is drawn into duct by fan and is spread sidewise over engine.

Transmission Nomenclature. Parts Nomenclature for Three-Speed Transmission. Am. Mach., vol. 63, no. 18, Oct. 29, 1925, p. 687, 1 fig. Standardized terms suggested by committee of Am. Gear Mfrs.' Assn.

AVIATION

Air-Mail Service. Operation of the Air Mail Service, J. E. Whitbeck. Soc. Automotive Engrs.—Jl., vol. 17, no. 5, Nov. 1925, pp. 486–489. Discusses personnel and ground facilities that have produced such excellent results in Air Mail Service, division supervisory organization; qualifications of flying personnel; maintenance of flying equipment; engine overhauls and engine life; composition of ground personnel; equipment of airways and airports; emergency-field layout and equipment.

Commercial. Commercial Air Transport, I. A. E. Edwards. Inst. Transport—Jl., vol. 6, no. 7, May 1925, pp. 378–384 and (discussion) 385–387. Author tells what has been done and what is being done in aviation; future expectations.

High Speeds. The Attainment of High Speeds. Aviation, vol. 19, no. 18, Nov. 2, 1925, p. 633. Discusses engineering achievements which render high speeds a possibility.

Maintenance and Repair Equipment. Maintenance, Repair and Servicing Equipment in Air Transport, A. Black. Am. Mach., vol. 63, no. 24, Dec. 10, 1925, pp. 921–923, 4 figs. Notes on airplane rebuilding and repair equipment; engine overhaul and repair equipment; airplane-servicing equipment; operating equipment; and field maintenance and miscellaneous equipment.

Mitchel Field Air Races. The Events of the New York Air Races. Aviation, vol. 19, no. 16, Oct. 19, 1925, pp. 533–538, 4 figs. Account of races in which ten contests were flown successfully.

Radio Signal. Air Mail Radio Signal Developed. Aviation, vol. 19, no. 20, Nov. 16, 1925, pp. 720–721. Invisible beacon, which guides pilots by day, night or in thick fog successfully tested by Air Mail Service.

Reliability in Transportation. Reliability as a Factor in Air-Transportation Efficiency, J. P. Van Zandt. Soc. Automotive Engrs.—Jl., vol. 17, no. 5, Nov. 1925, pp. 433–436, 6 figs. On-time records of passenger trains compared with Air-Mail Service; how prevailing winds affect regularity; planes are said to be more reliable than trains.

B

BALANCING MACHINES

Principles and Operation. Balancing of Machine Parts, E. Lehr. Eng. Progress, vol. 6, no. 9, Sept. 1925, pp. 302–305, 5 figs. Principles of action of balancing machines.

BEARINGS

Sleeve. Results Obtained through the Use of an Improved Type of Sleeve Bearing, J. S. Murray. Indus. Engr., vol. 83, no. 10, Oct. 1925, pp. 473–475, 5 figs. Details of operating conditions that were encountered before and after making several installations in a large steel plant.

BOILER FEEDWATER

Purification. Boiler-Feedwater Purification, A. S. Behrman. Mech. Eng., vol. 47, no. 11, Nov. 1925, pp. 909–910. Inquiry into present status of art, and into fundamental considerations responsible therefor. (Abridged.)

BOILER FURNACES

Air Preheaters. Air Preheaters in the Power Plant. Power Plant Eng., vol. 29, no. 18, Sept. 15, 1925, pp. 940–943, 6 figs. Description of types in general use and summary of results which may be expected from their use.

Boiler and Chain-Grate Operation. Practical Points on Boiler and Chain Grate Operation, J. T. Ruddick. Elec. Times, vol. 68, no. 1773, Oct. 8, 1925, pp. 400–401. Air and its calorific values; simple formula for flue-gas losses; effect of arch design on combustion rate; trouble with brickwork and bad furnace wall design; highest CO_2 not necessarily best operating point; cases of growth of cast-iron links; etc.

Design Tendencies. Progress and Tendencies in Furnace Design (Neuere Erkenntnisse und Richtlinien der Feuerungstechnik), F. Schulte. Gluckauf, vol. 61, no. 29, July 18, 1925, pp. 885–898, 17 figs. Notes on composition of solid fuels and its influence on combustion; volatile constituents and coke residue; air requirement, flue-gas volume and heating value; combustion of volatile constituents; combustion-chamber efficiency; combustion of coke residue; grate efficiency; etc.

Heat Losses from Walls. Heat Losses from Boiler Furnace Walls, L. B. McMillan. Power Plant Eng., vol. 29, no. 18, Sept. 15, 1925, pp. 944–946, 4 figs. Radiation and convection losses determined by air velocity as well as temperature difference.

Hog-Fuel-Burning. Burning Hog Fuel at Coos Bay Plant. Power, vol. 62, no. 17, Oct. 27, 1925, pp. 646–649, 4 figs. Inclined, stepped grates with Dutch ovens and special arches; 565 kw-hr. from fuel unit of 200 cu. ft. on 10-per cent load factor; tabular data of principal equipment at station of Mountain States Power Co., Oregon.

Pulverized Fuel. Boiler Furnace Design for Pulverized Fuel, J. G. Coutant. Combustion, vol. 13, no. 5, Nov. 1925, pp. 278–279, 4 figs. Changes in boiler-furnace design to meet conditions imposed by use of pulverized fuel, with particular reference to Ashley Street Station of Union Elec. Light & Power Co.

Radiant Heat Absorption in Pulverized Coal Furnaces, W. Lulofs. Elec. Times, vol. 68, no. 1773, Oct. 8, 1925, pp. 397–398, 1 fig. Author's views on theory developed by E. G. Ritchie, in Elec. Times of Aug. 27, as to effect of waterscreen and water-cooled sidewalls on radiant heat absorption in pulverized-fuel furnaces, in which he concluded by indicating that there was still ample efficiency to be won if boiler heat-absorbing surface were so disposed as completely to surround combustion chamber. Claims that theory is bound to lead to wrong results.

BOILERS

Cleaning of. A Plea for Justice for the Small Boiler, B. J. Parker. Mech. Eng., vol. 47, no. 11, Nov. 1925, p. 880. Practical suggestions for cleaning and maintenance of boilers, such as are used to generate steam in hotels, apartments, office buildings, laundries, etc. Abstracted from Cal. Safety News, June 1925.

Condensate Return to. Wabash River Station Employs Holly Loop, J. L. Peurifoy. Power Plant Eng., vol. 29, no. 21, Nov. 1, 1925, pp. 1097–1098, 2 figs. Plant of Indiana Electric Corp. reports satisfactory and economical use of system for direct return of condensate to boilers.

Edge Moor Single-Pass. A New Boiler Design. Combustion, vol. 13, no. 5, Nov. 1925, pp. 284–285, 1 fig. Discussion of new Single Pass Boiler developed by Edge Moor Iron Co.

Flame-Tube. Gas-Fired Flame-Tube Boilers for High Pressures (Gasgefeuerte Grossflammrohrkessel für hohen Druck), Fr. Schulte. Glückauf, vol. 61, no. 37, Sept. 12, 1925, pp. 1153–1157, 3 figs. Describes new type, developed by Ewald Berninghaus Boiler Works, Duisburg, suitable for high pressures and high superheat, yet competing with water-tube boiler in point of cost and space occupied; upper part of boiler is cylindrical with domed ends and has five corrugated flame tubes; lower part is plain cylindrical boiler with 158 smoke tubes; gives operating results.

High-Pressure. The Atmos. High-Pressure Boiler. Engineering, vol. 120, no. 3122, Oct. 30, 1925, pp. 538–540, 10 figs. Principal feature of design is that steam is generated in rapidly revolving tubes, which are so arranged that they may expand freely without setting up internal stresses.

BOILERS, WATER-TUBE

Marine. Boilers of the New Matson Line Steamship Malolo, C. J. Post. Mar. Eng., vol. 30, no. 10, Oct. 1925, pp. 582–584, 3 figs. There will be 12 water-tube boilers of Babcock & Wilcox marine type, built for a working steam pressure of 280 lb. gage and at least 100 deg. fahr. superheat; boilers will be equipped for burning oil under forced draft; total evaporative surface will be about 55,760 sq. ft. and superheating surface about 11,160 sq. ft.

BOLTS

Power-Plant Construction. Bolts for Use in Power-Plant Construction, Wm. P. Wood. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 1034–1038, 6 figs. Steel vs. wrought iron and screw stock; best carbon content for bolts; tentative specifications for high-temperature-alloy bolting material.

BORING MACHINES

Cylinder. Four-Bar Cylinder-Boring Machine. Engineering, vol. 120, no. 3122, Oct. 30, 1925, pp. 543–544, 2 figs. on p. 546. Designed for simultaneous boring operations on special machine and built for Indian State Rys.

BRAKES

Hydraulic Rail. Car Retarders Used in Europe. Ry. Age, vol. 79, no. 17, Oct. 24, 1925, pp. 743–746, 7 figs. Installations operated by hydraulic pressure are in service in Germany, Sweden and Denmark; system employed is based on invention of Dr. Froelich, railway superintendent of German Government; purpose is to eliminate necessity for employing car riders.

Operation and Maintenance. Loss, Damage and Discomfort Due to Improper Handling of Locomotive and Air Brakes. Ry. & Locomotive Eng., vol. 38, no. 10, Oct. 1925, pp. 284–287, 4 figs. Points out that best way to reduce damage to equipment and lading is for engineer to set brakes while slack is stretched, then gradually close throttle until train comes to rest with no steam in cylinders; fundamental enemies of modern air brake are uneven piston travel and leaks. Report presented to Traveling Engrs.' Assn.

BRASS

High-Strength. High Strength Brasses, M. Thibaud. Metal Industry (Lond.), vol. 27, no. 19, Nov. 6, 1925, pp. 434–435, 1 fig. General notes on composition and resulting strengths of high-strength brasses, as well as on methods of mixing, melting, casting, etc., on which special emphasis is laid. Abridged translation of paper presented before Franco-Belgian Foundry Congress.

Hot Pressings. The Industrial Uses of Hot Brass Pressings. Metal Industry (Lond.), vol. 27, no. 16, Oct. 16, 1925, pp. 361–362, 1 fig. Review of present stage of progress in manufacture and uses of hot-brass pressings; hollow pressings.

Nickel. Special Nickel Brasses, O. Smalley. Am. Inst. Min. & Met. Engrs.—Trans., no. 1508-E, Oct. 1925, 35 pp., 12 figs. Physical tests on nickel brass, tin brass, iron brass, nickel-aluminum brasses, iron-aluminum brass, nickel-iron-aluminum brasses and nickel-aluminum-tin brass, as cast or forged; impurities; problems of manufacture, crucible melting, electric furnace, casting, etc.

BRASS FOUNDRIES

Materials Handling. Handling Materials in a Brass Foundry, T. C. Flinn. Am. Foundrymen's Assn.—advance paper, no. 487, for mtg. Oct. 5–9, 1925, 7 pp. Analysis of materials handled in brass foundry having daily average output of 2500 lb. of castings, which required 152 tons of material handling to produce 1 ton of castings; principles followed in making analysis could easily be modified to meet iron-foundry conditions.

BRIQUETTING

Sawdust and Wood Shavings. The Briquetting of Sawdust and Wood Shavings, J. Petipas. Engineer, vol. 140, no. 3645, Nov. 6, 1925, pp. 483–484. Account of investigations and discoveries made in connection with agglomeration or briquetting of sawdust and wood shavings. Translated abstract of paper presented to Société des Ingenieurs Civils de France.

C

CAMS

Radial or Rotary-Engine. Radial and Rotary Engine Cams., P. Cormack. Automobile Engr., vol. 15, no. 207, Oct. 1925, p. 322, 2 figs. In notes referring to multilobe cam disk of radial or rotary engine, principle of operation is dealt with in manner which brings to light new possible cam arrangements of interest to designer.

CAR DUMPERS

Coal. Pennsylvania Builds Large Car Dumper in Record Time. Ry. Age, vol. 79, no. 19, Nov. 7, 1925, pp. 839–843, 7 figs. New facilities increase capacity 30 per cent at Sandusky, Ohio; completed in 7 months.

CAR WHEELS

Davis Steel. The Davis Steel Wheel and Its Manufacture in England, W. R. Martin. Iron & Steel Inst.—advance paper, no. 13, for mtg. Sept. 1925, 11 pp., 7 figs. on supp. plates. Describes manufacturing problems and slight changes made in design; result of destruction test of standard Davis wheel for British cars.

CARBURETORS

Calibrating Jets. Method of Calibrating Carbureter Jets Standardized in England. Automotive Industries, vol. 53, no. 20, Nov. 12, 1925, pp. 820–822, 4 figs. Engineering Standards Assn.'s plan provides for use of master jets at National Laboratory, and reference jets for regular work, latter calibrated from master jets with benzol.

CARS

Rustproofing. The Rustproofing of Materials, M. E. McDonnell. Mech. Eng., vol. 47, no. 11, Nov. 1925, pp. 875–880, 11 figs. Rust resistance of copper-bearing steel and savings possible through its use for car construction; protection of steel work by painting; baking process of drying painted cars.

CARS, FREIGHT

Box. Double Sheathed 55-Ton Box Cars for the D. L. & W., P. Alquist. Ry. Mech. Engr., vol. 99, no. 11, Nov. 1925, pp. 705–708, 7 figs. Built according to A.R.A. specifications; have carrying capacity of 125,000 lb. and weigh 43,700 lb.

CARS REFRIGERATOR

Short. Efficiency of Short Refrigerator Cars, R. G. Hill, W. S. Graham and R. C. Wright. Ry. Age, vol. 79, no. 20, Nov. 14, 1925, pp. 909–910. Load of 315 crates of celery refrigerate effectively; method of loading cars; ice consumption. Summary of U. S. Dept. Agriculture Bul., no. 1353.

CAST IRON

Graphitization. One of the Causes of Variations in Rates of Graphitization of White Cast Iron, A. Hayes and H. E. Flanders. Am. Foundrymen's Assn.—advance paper, no. 481, for mtg. Oct. 5–9, 1925, pp. 2–5, 4 figs.; also (abstract) in Foundry Trade Jl., vol. 32, no. 478, Oct. 15, 1925, p. 329, 4 figs. Study made as part of program for purpose of making feasible commercial use of greatly shortened annealing cycle; use of greatly reduced annealing period necessitates rather precise knowledge of factors that cause variations in rates of graphitizations of white cast irons of normal chemical composition; authors conclude that sulphur has great influence on rates of graphitization of white cast irons and difference in this case can be completely corrected by adding of small amount of manganese.

The Catalysis of the Graphitization of White Cast Iron by the Use of Carbon Monoxide Carbon Dioxide Mixtures When Applied Under Pressure, A. Hayes and G. C. Scott. Am. Foundrymen's Assn.—advance paper, no. 480, for Mtg. Oct. 5–9, 1925, 21 pp., 12 figs. Conclusions reached from results of investigation are: (1) at temperatures of 920 deg. cent. CO-CO_2 mixtures increase their rate of absorption of free iron carbide nearly 100 per cent; (2) during cooling at rates varying from 3½ deg. cent. per hr. to 400 deg. per hr. it inhibits almost completely graphitization in critical range; (3) action of gas mixture offers very convenient method of obtaining pearlitic matrix in present graphitization of white cast iron.

Gray, Effect of Heat Treatment. The Effect of Heat Treatment on the Properties and Microstructures of Grey Cast Iron and Semi-Steel, O. W. Potter. Am. Foundrymen's Assn.—advance paper, no. 462, for mtg. Oct. 5–9, 1925, 50 pp., 22 figs. Series of investigations dealing with effects on 10 different heat treatments, details of which are included; it is concluded that proper heat treatment can greatly improve general properties of gray cast iron and semi-steel; one important result is uniform hardness and elimination of massive cementite under annealing; to properly heat treat, correct critical temperature must be located and obtained in heat treatment; properties of gray cast iron and semi-steel can be greatly varied by heat treatment.

Gray, Refinement of. The Refinement of Gray Cast Iron (Wege und Ziele der Graugussveredelung), E. Diepschlag. Giesserei-Zeitung, vol. 22, no. 17, Sept. 1, 1925, pp. 517–521 and (discussion) 521–527, 13 figs. Possibilities of refining gray castings; refining by increasing strength through alloying and heat treatment; results of investigation of influence of alloys, C, Si, Mn, P, S and O on strength; it is concluded that reduction of carbon content and corresponding increase of silicon content in connection with suitable heat treatment increase strength; melting process.

Growth at High Temperatures. The Growth of Cast Iron at High Temperatures, E. Honegger. Brown Boveri Review, vol. 12, no. 10, Oct. 1925, pp. 202–209, 10 figs. Results of tests carried out by Brown, Boveri & Co. at their Baden works; investigations of influence of superheated steam; pearlitic cast iron.

Nickel and Nickel Chromium in. Nickel and Nickel-Chromium in Cast Iron, T. H. Wickenden and J. S. Vanick. Am. Foundrymen's Assn.—advance paper, no. 486, for mtg. Oct. 5–9, 1925, 60 pp., 13 figs. Discusses results of investigation of effects on properties of gray iron of nickel and nickel-chromium additions, and commercial applications of nickel and nickel-chromium cast iron; tests were made also on cast iron of high alloy content—up to 30 per cent nickel.

Oxygen Content. The Oxygen Content of Coke and Charcoal Cast Irons, J. R. Eckman, L. Jordan and W. E. Jominy. Am. Foundrymen's Assn.—advance paper, no. 479, for mtg. Oct. 5–9, 1925, 12 pp., 1 fig. General tendency of charcoal cast iron to exhibit greater strength and contain finer and more nodular form of graphitic carbon than coke cast iron of similar composition, melted and cast under identical conditions, has been attributed to higher oxygen in stronger irons; careful analyses of 12 charcoal and 8 coke irons failed to show that stronger irons contained more oxygen than weaker irons; values for oxygen in both stronger and weaker cast irons were very much lower than general range of values reported by Oberhoffer and Johnson; vacuum fusion method of analysis is more accurate than methods previously employed.

Perlit Process. A Description of the Perlit Process, H. J. Young. Foundry Trade Jl., vol. 32, no. 477, Oct. 8, 1925, pp. 294–295. Describes new method of production of gray iron castings under new conditions; process, in author's opinion, represents first distinct and definite advance in ordinary iron-foundry practice. See also (discussion) in no. 478, Oct. 15, 1925, pp. 331–332.

Phosphorus, Effect of. The Influence of Phosphorus on the Total Carbon Content of Cast Iron, J. T. MacKensie. Am. Foundrymen's Assn.—advance paper, no. 493, for mtg. Oct. 5–9, 1925, 24 pp., 8 figs. Investigation undertaken to see how small an increment of phosphorus would really affect total carbon enough to count in ordinary foundry processes, and how much would net effect be on fluidity and life of molten iron, and on strength, deflection and impact resistance of test bars.

Stresses, Reduction of. Relieving Casting Stresses, W. J. May. Mech. World, vol. 78, no. 2024, Oct. 16, 1925, pp. 307–308. Discusses methods for reduction or relief of stress, arising from unequal cooling of different parts, and other causes.

Synthetic. Synthetic Cast Iron and Its Possibilities for the Seattle District, G. S. Schaller. Am. Foundrymen's Assn.—advance paper, no. 484, for mtg. Oct. 5–9, 1925, 28 pp. Discusses factors entering into production of synthetic cast iron and pig, and shows possibilities of this process as applied to Seattle district, from which application can be made to other districts; historical review of development of process and discussion of types of furnaces erected and causes for development; present problems and materials used in process; application to Seattle district, taking up factors of material, supplies, labor, costs and markets.

CASTINGS

Hydraulic Cleaning. Cleaning Castings Hydraulically Proves Economical, E. C. Barringer. Iron Trade Rev., vol. 77, no. 21, Nov. 19, 1925, pp. 1267–1269 and 1318. Compared with old hand method, cleaning of castings by hydraulic pressure at Allis-Chalmers Mfg. Co., Milwaukee, is matter of minutes to hours; castings up to largest size of turbines, motors and heavy machinery of every sort, are swung by traveling crane into concrete chamber and deposited on turntable. See also article by R. A. Fiske, in Iron Age, vol. 116, no. 21, Nov. 19, 1925, pp. 1383–1385, 5 figs.

CENTRAL STATIONS

Fulham, England. Electricity Supply in Fulham. Elec. Rev., vol. 97, no. 2500, Oct. 23, 1925, pp. 659–661, 6 figs. Describes extensions carried out at Townmead Road power station of Metropolitan Borough of Fulham, England, trebling capacity of plant.

Germany. The Power Plant at Farge (Das Kraftwerk der "Kraftwerk Unterweser A.-G." bei Farge), F. Ohlmüller. Siemens-Zeit., vol. 5, no. 9, Sept. 1925, pp. 369–378, 12 figs. Design and construction of plant for 125,000 kva. near Bremen on Weser River, favorably situated for coal supply from land and sea; boiler plant, electric equipment and auxiliaries.

Maintenance and Changes. Keeping a Modern Station Up to Date. Jas. F. Brown. Elec. World, vol. 86, no. 17, Oct. 24, 1925, pp. 839–842, 3 figs. How, in period of five years, changes were made in Tulsa generating station from time to time to meet changing operating conditions and keep it up to desired standard of reliability of service, economy of operation and simplicity.

Neosho, Kan. Neosho Plant Burns Kansas Coal Economically. Power Plant Eng., vol. 29, no. 22, Nov. 15, 1925, pp. 1130–1136, 9 figs. Present-day combustion methods and greater reliability of supply give coal preference over oil and natural gas for plant of Kansas Gas & Elec. Co.; data of principal equipment.

New York City. Construction Methods on a 720,000-H.P. Generating Station, F. W. Skinner. Engineering, vol. 120, nos. 3119, 3121 and 3123, Oct. 9, 23 and Nov. 6, 1925, pp. 435–437, 501–504 and 563–566, 19 figs. Details of central station being built by New York Edison Co. at 14th St. and Avenue D, which will have nine 80,000-hp. turbo-generators and full auxiliary equipment; claimed to be larger than any other station yet completed in world; construction details.

Prime Movers for, Design of. Tendencies in the Present Design of Prime Movers for Central Stations, A. M. Greene, Jr. Engrs. & Eng., vol. 42, no. 9, Sept. 1925, pp. 246–249. Discusses early accomplishments, influence of traveling cranes, low-temperature exhaust, influence of steam turbine, bucket conveyor, mercury turbine, and regenerative cycles.

Rummelsburg, Germany. A New German Central Station, G. Klingenberg. Power, vol. 62, no. 22, Dec. 1, 1925, pp. 857–858. Details of design of Rummelsburg station, near Berlin, which will have ultimate capacity above 500,000 kw.; first section will include sixteen 18,820-sq. ft. boilers fired by pulverized coal, three 70,000 twin-tandem compound turbines, and three 10,000-kw. bleeder turbines for stage feedwater heating. Translated from Zeit. des Vereines deutscher Ingenieure, Oct. 10, 1925.

CLUTCHES

Friction. Design of Friction Clutches, J. Cryer. Machy. (Lond.), vol. 27, nos. 682 and 683, Oct. 22 and 29, 1925, pp. 105–108 and 137–139, 11 figs. Enumerates laws relating to friction of dry surfaces; deals with four types of friction clutches, cone, expanding ring, multi-disk, and centrifugal types, giving examples of each.

COAL HANDLING

Power Plants. Coal and Ash Handling Plant at East Greenwich Power Station, G. F. Zimmer. Indus. Mgmt. (Lond.), vol. 17, nos. 9, and 10, Sept. and Oct. 1925, pp. 431–433 and 467–470, 6 figs. Two hundred tons of coal are hourly converted at this power plant, situated on south bank of Thames river, into power which gives life to tramway system of London County Council; how necessary coal is unloaded from river craft, and brought to boilers and reserve stocks of power house; describes conveying installation.

High Speed Coal Towers at Brooklyn Edison Company's Hudson Avenue Station. Indus. Mgmt. (Lond.) vol. 12, no. 10, Oct. 1925, pp. 470–473, 4 figs. Description of coal-handling plant having capacity of 500 tons per hour.

The Cheapest Labor for the Power Plant. Indus. Mgmt. (N. Y.), vol. 70, no. 2, Aug. 1925, pp. 116–121, 14 figs. Points out that even small plant cuts its power bill by mechanical handling of coal and ashes.

COMPRESSED AIR

Cooling and Drying. Cooling and Drying Compressed Air, J. B. Leonard. Ry. Mech. Engr., vol. 99, no. 11, Nov. 1925, pp. 721–722, 1 fig. Describes installation, at one of car shops of Mich. Cent., Detroit, Mich., of system for cooling and drying compressed air.

CONDENSERS, STEAM

Leakage Tests. Code on Instruments and Apparatus. Mech. Eng., vol. 47, no. 11, Nov. 1925, pp. 920–926, 2 figs. Preliminary draft of Chapter 21, dealing with condenser-leakage tests.

Tube Failures. Causes of Condenser Tube Failures. Power Plant Eng., vol. 29, no. 22, Nov. 15, 1925, pp. 1143–1144, 3 figs. Mechanical and chemical actions, latter due in part to crystal arrangement of metals employed, may cause tube to fail.

CONVEYORS

Mail Tubes. Mechanizing Internal Communication by Mail Tubes and Conveying Plants (Die Mechanisierung des Innenverkehrs nach Ausführungen der A. G. Mix & Genest, Telephone- und Telegraphen-Werke Abt. Rohrpost und Förderanlagen), C. Beckmann. Elektrotechnische Zeit., vol. 46, no. 41, Oct. 8, 1925, pp. 1540–1547, 20 figs. Details of design and operation of Mix and Genest high-pressure system of internal mail tubes, as applied to Berlin and Paris wholesale houses, post offices in Berlin, Oslo, Rotterdam, etc.

COOLING TOWERS

Operation. The Theory of Cooling-Tower Operation, D. K. Dean. Power, vol. 62, no. 20, Nov. 17, 1925, pp. 754–757, 6 figs. Presents relationships of various factors governing such operation.

CORES

Core Oils. The Qualities of Commerical Core Oils, H. L. Campbell. Am. Foundrymen's Assn.—advance paper, no. 467, for mtg. Oct. 5–9, 1925, 12 pp., 5 figs. Study of properties of 23 commercial core oils; chemical and physical properties of core oils were obtained as well as physical properties of cores made with oils, in order to note any relationship in these characteristics; properties determined were specific gravity, refractive index, iodine number, and unsaponifiable matter; summary of conclusions reached.

COST ACCOUNTING

Inventory Control. The Control of Inventory Through the Scientific Determination of Lot Sizes, H. S. Owen. Indus. Mgmt. (N. Y.), vol. 70, no. 5, Nov. 1925, pp. 289–295. Building charts for order-quantity determination.

Price Control and. Cost Accounting and Price Control, D. L. Moran. Indus. Mgmt. (Lond.), vol. 17, no. 19, Sept. 1925, pp. 445–447. Discusses selling policy, uniform methods of costing, method of stabilization, issue of stocking orders, etc. Paper read before Fourth Annual Costing Conference held in London.

CRANES

Accessories. Increasing the Usefulness of Cranes and Hoists. Indus. Mgmt. (N. Y.), vol. 70, no. 2, Aug. 1925, pp. 96–102, 12 figs. Various types of buckets, grapples, slings, magnets, and their applications.

Electric. The Design and Construction of Electric Cranes, D. Adamson. Engineering, vol. 120, nos. 3123 and 3124, Nov. 6 and 13, 1925, pp. 592–593 and 622–624, 24 figs. Points of detail of electric overhead traveling cranes, such as main structure, wheels and axles, gearing, ropes and hooks, with reference to electric motors and controllers, Paper read before Manchester Assn. Engrs.

Electric Gantry. 15-Ton Electric Gantry Crane for India. Engineer, vol. 140, no. 3643, Oct. 23, 1925, p. 443, 2 figs. Details of crane constructed by Bedford Eng. Co. to order of India Office.

Foundry. Dust-Proof Foundry Cranes. Foundry Trade Jl., vol. 32, no. 479, Oct. 22, 1925, pp. 347–349, 6 figs. Describes overhead electric traveling crane introduced by S. H. Heywood & Co., Reddish, specially designed for use in foundries and other places where dust and dirt are inevitable, with object of reducing to minimum breakdowns and stoppages associated with unprotected open-type overhead travelers used under such conditions.

Transport in Foundries. Foundry Trade Jl., vol. 32, no. 481, Nov. 5, 1925, pp. 385–386, 3 figs. Characteristics of type of crane introduced by Wellman Smith Owen Eng. Corp., London, which has been standardized by this firm; it is electric overhead traveling type designed primarily to meet requirements of iron and steel foundries.

CUPOLAS

Charging. Mechanically Charging the Cupola, E. F. Rogers. Iron Age, vol. 116, no. 23, Dec. 31, 1925, pp. 1514–1515, 5 figs. Equipment for handling pig iron and sprues and gates in Cincinnati foundry; saving in labor and improvement in product.

Flames. Cupola Flames. Metal Industry (Lond.), vol. 27, no. 16, Oct. 16, 1925, pp. 367–368. Describes what appearance of flames above charge and in stack above charging door indicate; continuous flaming above charge; probable defects it indicates; color of flame in stack.

Iron-Temperature Recorders. Continuous Iron Temperature Recording, H. W. Dietert and Wm. M. Myler, Jr. Am. Foundrymen's Assn.—advance paper, no. 495, for mtg. Oct. 5–9, 1925, 15 pp., 6 figs. Describes continuous iron-temperature recorder attached to cupola spout which indicates by means of scale and pointer the temperature of molten iron at any period of melt; it also makes continuous record on chart of temperature throughout heat; study of charts made by this machine enables foundryman to give specific instructions to cupola tender so as to produce iron within definite temperature range.

Melting Rate and Tuyere Ratios. Cupola Melting Rate as Affected by Tuyere Ratios, J. Grennan. Am. Foundrymen's Assn.—advance paper, no. 477 for mtg. Oct. 5–9, 1925, 7 pp., 1 fig. Series of experimental heats were run to determine whether any differences could be noticed in cupola melting when tuyere area ratios were changed; observations were taken of air pressures in wind belt and cupola, together with temperature of iron at spout as determined by optical pyrometer; author concludes that there is nothing vital in size of tuyeres and that small tuyeres do not have marked influence on melting.

Refractory Lining. The Effect of Variations in Cupola Practice on the Life of the Refractory Blocks, Jas. T. MacKenzie. Am. Ceramic Soc.—Jl., vol. 8, no. 11, Nov. 1925, pp. 720–733 and (discussion) 733–734. Discusses chemical, mechanical and physical influences acting on cupola linings and their combined effects; describes common practice in lining, preparation and charging of cupola; effect of daubing practice, character of fuel, metal, flux and blast; points out injurious effect of oxidation resulting from thin or rusty scrap and from too high velocity of blast.

Superheating Iron in. Superheating Iron in the Cupola, S. J. Felton. Am. Foundrymen's Assn.—advance paper, no. 476, for mtg. Oct. 5–9, 1925, 7 pp. Discusses relative effects on temperature of cupola iron of oxidation of metal, differences between melting and freezing-range of cast iron and heat absorption by conduction, radiation and convection; cupola heat balance is said to be of significance only from standpoint of determination of amount of heat lost from hearth and bottom; methods of increasing superheat of cupola metal.

Thermal Control. The Regulation of Cupolas from Heat-Economical Standpoint (Die wärmewirtschaftliche Einstellung des Kuppelofens), E. Piwowarsky and F. Meyer. Stahl u. Eisen, vol. 45, no. 26, June 25, 1925, pp. 1017–1022, 7 figs. Description of cupola installation and experimental equipment; charging; values obtained and experimental results.

CUTTING METALS

Research in. Research in Metal Cutting, O. W. Boston. Am. Mach., vol. 63, no. 21, Nov. 19, 1925, pp. 805–806, 4 figs. Discovery of fundamental facts is aim rather than investigation dealing only with practical results.

CYLINDERS

Airplane, Machining. A Difficult Piece of Machine Work, A. T. Gregory. Am. Mach., vol. 63, no. 18, Oct. 29, 1925, pp. 685–686, 7 figs. Finishing interior of cylinder casting of unusual shape; design of cams that furnish only guide for two cutting tools.

Hollow, Cold Working. Effect of Cold Working on the Strength of Hollow Cylinders, F. C. Langenberg. Am. Soc. Steel Treating—Trans., vol. 8, no. 4, Oct. 1925, pp. 447–471 and (discussion) 471–473, 16 figs. Describes process of manufacture in which physical properties of large-size simple hollow cylinders may be greatly increased over usual properties obtained; discusses principles involved in computation of strength of gun tubes and jackets; apparatus employed in manufacture of gun tubes by cold-working progress; effect of annealing operations on elastic strength of cold-worked simple and compound cylinders, after different amounts of cold working had been applied.

Lapping. Precise Cylindrical Lapping, P. M. Mueller. Abrasive Industry, vol. 6, no. 10, Oct. 1925, pp. 295–299, 11 figs. Accurate lapping within exceedingly close limits is made possible with special equipment; elaborate measuring means are employed.

D

DIE CASTING

Metallographic Problems. Die Casting (Der Spritzguss und seine Aufgaben für die Metallkunde), L. Frommer. Zeit. für Metallkunde, vol. 17, nos. 8 and 9, Aug. and Sept. 1925, pp. 245–250 and 287–293, 13 figs. Comparison of die-casting and sand-casting processes; stresses in die castings during solidification and during removal from mold; characteristic curve is plotted which shows properties of material in relation to temperature; determination of adaptability of alloy for die casting and determination of strength properties of casting material after die casting; development of testing method.

DIESEL ENGINES

Centrifugal Compressors for. Centrifugal Compressors for Diesel Engines, S. A. Moss. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 1075–1084, 12 figs. Installations of centrifugal compressors for scavenging and supercharging; centrifugal compressors for Diesel Engines; advantages of centrifugal compressors for 2-cycle scavenging; supercharging experiments; theory of supercharging Diesel engine; exhaust-gas turbine for scavenging and supercharging.

Costs. Diesel Engine Costs. Power Plant Eng., vol. 29, no. 22, Nov. 15, 1925, p. 1146. Installation and operation expenses gathered by Committee of Great Lakes Division, N. E. L. A.

Efficiency. The Diesel Engine and Its Overall Economy, C. B. Jahnke. New England Water Wks. Assn.—Jl., vol. 39, no. 2, June 1925, pp. 105–134, 16 figs. Discusses oil situation of United States; status of Diesel and steam-engine efficiency; estimated total cost of steam, motor, and oil-engine-driven plants; actual oil-engine-plant operating costs.

Flour-Mill. Experience with Diesel Engines in a Kansas Flour Mill, Chas. Dalrymple. Power, vol. 62, no. 21, Nov. 24, 1925, pp. 793–794, 1 fig. Account of satisfactory performance of Diesel-engine installation in plant of Red Star Milling Co., Wichita.

Forge Plants. Diesel Engine Experience in a Modern Forge Plant, J. P. Harbeson, Jr. New England Water Wks. Assn.—Jl., vol. 39, no. 2, June 1925, pp. 138–140. Cites facts and figures that have occurred and are occurring in operation of two Diesel engine generator sets under author's supervision at Camden Forge Co., Camden, N. J., together with reasons for adopting this source of power, troubles encountered and how overcome, and results obtained.

Submarine. Diesel Engines in Submarines, E. C. Magdeburger. Am. Soc. Naval Engrs.—Jl., vol. 37, no. 3, Aug. 1925, pp. 572–610, 29 figs. partly on supp. plates. Essential requirements for Diesel engines in submarines; first Diesel engines installed in submarines; Nelseco 4-cycle engine, Busch-Sulzer 4-cycle engine, S-boat engines, Nelseco 8-cylinder 4-cycle engines; critical speeds; T-boat engines. Busch-Sulzer 2-cycle engines for "S" class, Polar and Craig engines, Bureau type 4-cycle engines, V-boat engines.

Trucks and Tractors. Diesel Engine Adapted to Trucks and Tractors, B. R. Dierfeld. Automotive Industries, vol. 53, no. 18, Oct. 29, 1925, pp. 730–733, 10 figs. Benz product is aluminum casting with iron cylinder liners; fuels sprayed mechanically into ignition chamber.

DRILLING

Automobile Parts. Multiple-Drilling Operations in the Studebaker Plant, W. F. Sandmann. Am. Mach., vol. 63, no. 21, Nov. 19, 1925, pp. 807–809, 6 figs. Drilling engine crankcase; using multiple drill on small parts: use of rotating-table set-ups; inverting multiple drill.

DRILLING MACHINES

Ball-Bearing Sensitive. Ball-Bearing Sensitive Drilling Machine. Mech. Wld., vol. 78, no. 2021, Sept. 25, 1925, pp. 239–240, 4 figs. Describes new drilling machine brought out by James Archdale & Co., Ltd., Birmingham, England, designed to meet demand for a drill for light work such as small electrical components, telephone and wireless apparatus, and similar parts.

Radial. New Light Radial Drilling Machine. Machy. (Lond.), vol. 27, no. 680, Oct. 8, 1925, pp. 37–38, 2 figs. Describes flat-belt-drive drilling machine intended for power drive either from lineshaft or by electric motor through reduction gearing.

E

EDUCATION, ENGINEERING

Danzig. The Technical High School at Danzig (Die Technische Hochschule zu Danzig), Roessler. Elektrotechnische Zeit., vol. 46, no. 41, Sept. 3, 1925, pp. 1332–1337, 5 figs. Details of building and equipment, especially of electrotechnical and machinery laboratories, heating power plant in course of construction, welfare arrangements for students.

EJECTORS

Pneumatic. Pneumatic Ejectors, E. Johnstone-Taylor. Mech. Wld., vol. 78, no. 2020, Sept. 18, 1925, pp. 224–226, 6 figs. Description of pneumatic ejector as a means of raising liquids; is entirely automatic, and pumping medium is compressed air; working of ejectors; self-contained sets; ejectors in tandem; automatic engine equipment.

ELECTRIC FURNACES

High-Frequency Induction. High-Frequency Induction Furnace, D. F. Campbell. Iron & Steel Inst.—advance paper, no. 3, for mtg. Sept. 1925, 7 pp., 2 figs. Advantages of high-frequency furnaces for research work are very great, owing to speed with which small heats can be made, either in vacuo or in air.

New High Frequency Induction Furnaces, D. Willcox. Am. Foundrymen's Assn.—advance paper, no. 485, for mtg. Oct. 5–9, 1925, 8 pp., 5 figs. Describes furnace which was developed in effort to make ideal brass-melting furnace; application to nickel-iron melting, to special and to heat treating.

Iron-Melting. The Electric Melting of Cast Iron, Geo. E. Lamb. Am. Foundrymen's Assn.—advance paper, no. 464, for mtg. Oct. 5–9, 1925, 16 pp. Discusses use of electric furnace in melting cast iron in localities where cost of suitable materials for cupolas for melting are such that electric furnace can compete disregarding entirely quality of iron produced by electric melting process; describes melting equipment of plant with which author is associated in Pacific northwest; operation of furnace; type of lining used was acid type consisting of silica brick walls and roof and cotton made of silica sand with binder rammed in place; troubles encountered in melting alternate heats of iron and steel; practices tried in endeavor to keep down carbon in steel heats following those of iron; tabular data.

Melting, Operation of. Notes on the Operation of a 1½ Ton Electric Furnace Producing a Large Tonnage, A. W. Gregg and N. R. Knox. Am. Foundrymen's Assn.—advance paper, no. 491, for mtg. Oct. 5–9, 1925, 14 pp. Records performance of electric furnace which has been pushed for output over period of 1 year; type of melting practice followed was basic and discussion is largely devoted to shop details which do not find their way into books on electric-furnace practice; discusses factors in securing long life for refractories, describing methods followed in relining sides, bottoms and covers; precautions followed in burning in linings; tabular data of costs of all items of operation and test results of heats.

Melting, Refractory Problem. Some Refractory Problems in the Non-Ferrous Electric Furnace Casting Shop, G. F. Hughes. Am. Foundrymen's Assn.—advance paper, no. 469, for mtg. Oct. 5–9, 1925, 15 pp., 6 figs. Discusses refractory problem when using induction and rocking-arc electric melting furnaces to melt yellow brass, copper-tin alloys and that which has been done and remains to be done to bring induction furnace into field where its use may be universal in non-ferrous melting; discusses lining construction of induction furnace together with method of operation to secure best results; careful preheating of newly lined furnace is one of most important factors; consideration of refractory cements.

Moore Rapid. The Moore Rapid Electric Furnace (Der Moore-Rapid-Elektroofen), V. Szák. Giesserei-Zeitung, vol. 22, no. 19, Oct. 1, 1925, pp. 589–594, 4 figs. Describes 4-ton electric furnace of American make, method of operation and melting results.

Resistance. An Electric Resistance Furnace for Laboratory Roasting, A. T. Fry. Chem. Eng. & Min. Rev., vol. 17, no. 204, Sept. 5, 1925, pp. 479–481, 1 fig. Describes electric resistance furnace installed by E. R. Crutcher in research laboratory of Mt. Lyll M. and R. Co., Ltd., under direction of R. Sticht.

60-K.V.A. Electric Resistance Furnace. Iron & Coal Trades Rev., vol. 111, no. 3003, Sept. 18, 1925, p. 455, 2 figs. Has heating chamber 60 in. long by 40 in. wide by 20 in. high; is of resistance type of 60 kva., working on a 440-volt a.c. circuit; may be adapted for operating on any ordinary low-tension supply whether direct current, single-, two- or three-phase alternating current; use of a transformer is thus unnecessary.

Types and Applications. Electric Heat as Used in Modern Industry, C. L. Wilson. Indus. Mgmt. (N. Y.), vol. 70, no. 5, Nov. 1925, pp. 277–282, 7 figs. Requirements for various heat-treating industrial processes; analysis of different kinds of electric furnaces and their capabilities.

ELECTRIC WELDING

Butt-Welding Multi-Throw Cranks. Butt-welding Multi-throw Cranks, A. M. Lount. Machy. (N. Y.), vol. 32, no. 3 Nov. 1925, pp. 222–223, 5 figs. Cutting off stock, bending and forging sections; turning pins and cutting off sections; welding sections together; turning ends and line bearings.

ELECTRIC WELDING, ARC

A. C. Welding Regulation. Arc Welding, O. Thanning. Brown Boveri Rev., vol. 12, no. 9, Sept, 1925, pp. 186–190, 6 figs. Discusses the various systems of regulation employed for arc welding by direct current, which are: generator voltage constant, regulation by series rheostat; generator voltage variable, series resistance fixed; generator characteristics sharply falling, no series resistance.

Cast Iron. Electric Welding (Ueber elektrische Schweissung), H. Neese. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 45, Nov. 7, 1925, pp. 1409–1410, 5 figs. Notes on arc welding of cast iron; compares cold welding of gray cast iron with welding of ingot steel; explanation of hard zone occurring with cold welding; hot welding is most desirable process at present time; method employed and successful results; structural characteristics.

Tank Construction. Automatic Arc Welding in Tank Construction, W. L. Warner. Am. Mach., vol. 63, nos. 17 and 18, Oct. 22 and 29, 1925, pp. 643–645 and 689–692, 6 figs. Oct. 22: Development of arc welding to replace riveting; welding methods for tanks; design of tanks to be welded; strength formulas. Oct. 29: Automatic hand welding; tests on hand and automatically welded tanks; safety factor; specifications for design.

ELECTRIC WELDING, RESISTANCE

Tests. Mechanical and Metallographic Test of Electric Resistance Welding (Mechanische und metallographische Prüfung von elektrischen Widerstandschweissungen), E. Bock. Maschinenbau, vol. 4, no. 20, Oct. 1, 1925, pp. 989–993, 32 figs. on supp. plates. Discusses structure of material; compares micrographs of weld joints and transition zones for butt and fusion welding; gives hardness tests of welds and adjacent points.

EMPLOYMENT MANAGEMENT

Personnel Forms. An Analysis of Personnel Forms, D. R. Craig. Indus. Mgmt. (N. Y.), vol. 70, no. 2, Aug. 1925, pp. 122–124, 6 figs. Keeping red tape at minimum by studying current practice in personnel work; service records; how these forms can be used.

ENGINEERING

Measurement of Work. Measurement of Engineering Work, T. G. Price. Elec. Light & Power, vol. 3, no. 10, Oct. 1925, pp. 15–17 and 84, 11 figs. Describes system for measurement of effort expended and amount of engineering work accomplished, devised and placed in operation in Distribution Engineering Division of Commonwealth of Edison Co. of Chicago, purpose of which is to provide engineer of distribution, heads of various subdivisions under his jurisdiction, and interested executives of company with information as to volume of work, effort, cost, etc.

F

FACTORIES

Location. Taking Advantage of "Complementary" Plants, J. A. Piquet. Indus. Mgmt. (N. Y.), vol. 70, no. 5, Nov. 1925, pp. 313–316. Discusses question of location near other plants whose needs or products fit in at one or other end of plant in question; points out that this is often matter, not of relocating, but of attracting such plants to locate in vicinity.

FATIGUE

Industrial. Carbon Dioxide as an Index of Fatigue, W. N. Polakov. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 1043–1046, 3 figs. Suggests simple and practical procedure for reducing (if not eliminating) ill effects of fatigue through joint study of work and workman; apparently immediate and reliable indications offered by measurement of CO_2 content in exhalations of workman will enable management to organize work so that organism of workman will produce maximum result with minimum exertion.

FIREBRICK

Air-Furnace Melting. Principal Refractory Problems of the Malleable Cast Iron Foundry, H. A. Schwartz. Am. Ceramic Soc.—Jl., vol. 8, no. 11, Nov. 1925, pp. 708–711. Describes necessary conditions under which firebrick are used in air-furnace melting, and outlines elementary relations between fuel economy and refractory economy, including loss of use; suggests that principal fields for improvement lie in developing refractories more resistant to slags for side walls, and more resistant to changes of temperature for furnace roofs; refractory materials now known seem to fail due to lack of resistance to thermal stresses.

FITS

Desirability Diagrams. Measuring Systems and Tolerance Limits, P. J. Darlington. Mech. Eng., vol. 47, no. 11, Nov. 1925, pp. 903–905, 4 figs. Fit-desirability diagrams and what they show about systems of measuring.

Limit System. A System of Limits for Different Kinds of Fits, C. D. Albert. Mech. Eng., vol. 47, no. 11, Nov. 1925, pp. 901–903. Hole vs. shaft as basis of fit system; best method of expressing tolerances; Newall and A.E.S.C. systems; standard method needed to express tolerances.

Standard. Status of the Fit Problem in Germany and Abroad (Der Stand der Passungsfrage in Deutschland und im Auslande II), K. Gramenz. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 45, Nov. 7, 1925, pp. 1411–1417, 10 figs. Compares standard fits of England, Italy and Sweden with DIN (German Industrial Standards Committee) fits.

FLIGHT

Bird. The Flight of Birds, Fullerton. Roy. Aeronautical Soc.—Jl., vol. 29, no. 178, Oct. 1925, pp. 535–543, 6 figs. Explains principles upon which flapping flight of birds depends and shows how velocities, power expended and gliding angles can be approximately calculated; birds are considered to be flying on horizontal course with constant velocity. See also Notes by Oscar F. Gnosspeliue, pp. 543–547, 1 fig.

Flapping. Theory of Flapping Flight, A. Lippisch. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 334, Oct. 1925, 11 pp., 8 figs. on supp. plates. Gives graphic and mathematical method, which renders it possible to determine power required, so far as it can be done on bases of wing dimensions. Translated from Flugsport, June 17, 1925.

FLOW METERS

Application. Practical Application of Steam Flow Meters. Steam Power, vol. 4, July and Aug. 1925, pp. 6, 8 and 10; and 6 and 10, 8 figs. Describes practical application in power plant.

FLOW OF FLUIDS

Curved Passages. Flow of Fluids in Curved Passages, J. Eustice. Engineering, vol. 120, no. 3124, Nov. 13, 1925, pp. 604–605, 4 figs. Brief account of recent experiments on flow in rectangular passages; including explanation of occurrence of peculiarities in resistance which have been observed in pipe bends. Paper presented to Brit. Assn.

FORGINGS

Brass Bars and Sections. British Standard Specification for Brass Bars and Sections Suitable for Forgings and Drop Forgings. Brit. Eng. Standards Assn., no. 218, June 1925, 8 pp., 7 figs. Specification covering quality of material, methods of manufacture, freedom from defects, provision of test pieces, mechanical tests, re-tests, inspection, and testing facilities. Appendix giving forms of British standard tensile test pieces.

Ring, Manufacture of Large. A Method of Manufacturing Large Ring Forgings, W. L. Blankenship. Am. Soc. Steel Treating—Trans., vol. 8, no. 4, Oct. 1925, pp. 474–483, 10 figs. Presents unique method for production of large ring forgings when using forging press or steam hammer having insufficient space between supporting columns to accommodat forging; describes method employed in production of 8-in., 56-caliber training circle forging starting with split I-bar; method of bending, opening and finish; method of heat treating finished forging.

FOUNDRIES

Gray Iron. Saving the Gray Iron Foundry, R. Moldenke. Iron Age, vol. 116, no. 18, Oct. 29, 1925, pp. 1165–1167. Steps are recommended to protect industry from encroachments of steel and malleable castings and of forgings and stampings; program for checking retrogression.

Heavy Castings. Handling Heavy Castings. Foundry, vol. 53, no. 20, Oct. 15, 1925, pp. 814–817, 6 figs. Describes foundry of Dominion Eng. Works, Montreal, Can., engaged in manufacture of paper-making, hydraulic and hydroelectric machinery and general heavy foundry and machine-work business; mold-drying equipment; coke-fired ovens; charging platform.

Management. Foundry Progress: Past, Present and Future, J. D. Towne. Am. Foundrymen's Assn.—advance paper, no. 473, for mtg. Oct. 5–9, 1925, 13 pp. Early historical developments of ferrous-casting industry; discusses reasons why industries' management has not, as whole, developed as has that of certain other industries; states that average foundry manager misunderstands meaning and extent of modern methods of management; author believes that planning and manufacturing are two headings under which most progress is being made; gives detailed results obtained by analytical study of cleaning-room operations of steel foundry.

Railway Repair Shops. Castings a Factor in C. P. R. Service, A. Murphy. Can. Foundryman, vol. 16, no. 9, Sept. 1925, pp. 23–25, 4 figs. Describes how rolling stock is maintained at Angus shops of Can. Pac. Ry.; two large foundries are operated, one devoted entirely to making of chilled iron wheels, other to all types of gray-iron castings, weighing from several ounces to 10-ton die for flanging press in boiler shop.

FOUNDRY EQUIPMENT

Improved Accessories. Improved Foundry Tackle, H. V. Fell. Foundry Trade Jl., vol. 32, no. 477, Oct. 8. 1925, pp. 298–300, 23 figs. Describes Vickers patent pattern plate which consists of perforated steel plate, dowel holes of which have been drilled at determined equidistances, and stamped with reference numbers; molding-box locating arrangement; lifting device for cores and drawbacks; foundry paint spray.

FUELS

Chemistry. Progress in Chemistry and Use of Fuels (Fortschritte auf dem Gebiete der Brennstoffchemie und Brennstoffverwertung), W. Zisch. Brennstoff- u. Wärmewirtschaft, vol. 17, no. 15, Aug. (1st no.), 1925, pp. 293–298. Reviews recent work done in field of solid, liquid and gaseous fuels.

Selection of. Factors Affecting the Selection of Fuel. Forging—Stamping—Heat Treating, vol. 11, no. 10, Oct. 1925, pp. 366–370, 3 figs. Ultimate choice should be based on cost per unit of goods manufactured, and various secondary advantages of convenience and cleanliness.

[See also OIL FUEL; PULVERIZED COAL.]

FURNACES

Iron-Melting. The Wüst Oil-Fired Furnace, T. Klingenstein. Engineering, vol. 120, no. 3125, Nov. 20, 1925, p. 653, 5 figs. Details of furnace designed by Prof. Wüst, of Aachen, Germany, which is combination of hearth and shaft types, in which oil consumption is much reduced by special arrangements made for circulation of gases and preheating of blast. Translated abstract from Stahl u. Eisen, Aug. 27, 1925.

FURNACES, INDUSTRIAL

Efficiency. Industrial-Furnace Efficiency, V. J. Azbe. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 1061–1064. Heat losses encountered in industrial-furnace operation; dilution of products of combustion; application of waste-heat boilers to industrial furnaces; incomplete combustion; furnace design.

Industrial Furnaces, W. Trinks. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 1065–1071, 19 figs. Comparison of boiler and industrial furnaces; fuels for industrial furnaces; furnace efficiency and its improvement; electrically heated furnaces; automatic temperature control; selection of fuels; determination of furnace sizes, etc.

Gas. The Use of Gas in Industrial Furnaces, F. A. McLean. Can. Machy., vol. 34, no. 17, Oct. 22, 1925, pp. 21–22, 2 figs. Demonstrates claim that a high-pressure air system with induction blower is particularly suitable for operating tool hardening, heat treating, enameling and other types of gas furnaces, in factories and industrial plants.

G

GAGES

Templet and Position. Templet and Position Gauges, H. T. Wright. Machy. (Lond.), vol. 27, no. 681, Oct. 15, 1925, pp. 65–69, 15 figs. Methods of obtaining high accuracy; examples from airplane-engine practice.

GAS

Heating Value of. Relation between Heating Value of Gas and Its Usefulness to the Consumer, A Critical Review of the Published Data, E. R. Weaver, U. S. Bur. Standards, Technologic Paper No. 290, July 21, 1925, pp. 347–463, 51 figs. Character of available data; direct observations upon use of gas; discussion of direct evidence regarding usefulness of various qualities of gas; data regarding quantity of gas used by customers and its relation to usefulness of gas; discussion of changes in volume of gas used before and after a change of heating value.

GAS ENGINES

Blast-Furnace. The Gas Engines of the Maryland Plant of the Bethlehem Steel Company, A. A. Raymond. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 1007–1008. Details of installation of 18 large engines using blast-furnace gas, together with data of tests and operating records.

GAS TURBINES

Holzwarth. The Holzwarth Gas and Oil Turbine. Mar. Eng., vol. 30, no. 10, Oct. 1925, pp. 570–574, 7 figs. Is of constant-volume combustion or intermittent explosion type in which a slightly pre-compared mixture of gas or oil and air is burned at constant volume in a number of explosion chambers, gases being allowed to expand in turbine nozzles only after complete combustion has occurred in chambers; developments in Germany show commercial possibilities; tests being made on 5000-kw. turbine.

GASOLINE

Anti-Knock Properties. Anti-Knock Properties of Gasoline Depend on Cracking, A. L. Clayden. Automotive Industries, vol. 53, no. 20, Nov. 12, 1925, pp. 813–816, 5 figs. Detonation can be combatted by changes in fuel production; cracked gasoline is more subject to control than straight runs; blending improves latter.

Research Results. Research to Determine Fuel Needs. Soc. Automotive Engrs.—Jl., vol. 17, no. 5, Nov. 1925, pp. 416–417, 1 fig. Review of semi-annual motor-gasoline survey, issued by Bureau of Mines; desirable difference in volatility in winter and summer to be studied.

GEAR CUTTERS

Disk, Inspection of. Recommended Practice for the Inspection of Disk Gear Cutters. Am. Mach., vol. 63, no. 19, Nov. 5, 1925, p. 737. Report made by Inspection Committee of Am. Gear Mfrs.' Assn. and adopted as recommended practice.

GEAR CUTTING

Sykes Generator. Sykes Herringbone Gear Generator. Iron Age, vol. 116, no. 18, Oct. 29, 1925, pp. 1189–1191 and 1225, 5 figs. Machines now being placed on market; method of cutting continuous gears, and operation of equipment.

Generating Herringbone Gears, W. E. Sykes. Machy. (N. Y.), vol. 32, no. 3, Nov. 1925, pp. 233–236, 6 figs. Sykes process of cutting double helical gears of continuous-face type, and important features of generators used.

GEARS

Design. Gears (Zahnräder), E. Toussaint. Praktischer Maschinen-Konstrukteur, vol. 57, no. 46, Dec. 2, 1924, and vol. 58, nos. 6, 7, 11, 13, 15, 21, 24, 25 and 26, Feb. 10, 17, Mar. 17, 31, Apr. 14, May 26, June 16, 23 and 30, 1925, pp. 617–620, 81–84, 97–100, 161–165, 193–197, 225–230, 322–326, 369–372, 385–387 and 401–403, 89 figs. Discusses gear wheels, their design and construction commensurate with modern increased sizes of machinery; fundamentals of gears, curves of teeth, involute teeth, etc. (To be contd.)

Efficiency and Durability Tests. Recent Tests on the Efficiency and Durability of Gearing, C. W. Ham. Machy. (N. Y.), vol. 32, no. 3, Nov. 1925, p. 197. Results of tests carried out by author and J. W. Huckert, using testing machine designed and built by W. Lewis; summary of conclusions in regard to durability. (Abstract.) Paper read before Am. Gear Mfrs.' Assn.

Internal. A New Development in Internal Gearing—Comment, A. Fisher. Machy. (Lond.), vol. 27, no. 683, Oct. 29, 1925, pp. 147–149, 5 figs. Analyzes tooth action of new gearing, described in previous issue of same journal, and compares it more closely with tooth action of ordinary involute gearing than is done in original article, so as to arrive at clearer view of relative value of two systems; author concludes that new development in internal gears is theoretically and fundamentally incorrect, and odontoidal tooth contact is non-existent.

Standardization. Standardization by Gear Manufacturers. Machy. (N. Y.), vol. 32, no. 3, Nov. 1925, pp. 194–197, 3 figs. Review of papers and reports presented before Am. Gear Mfrs.' Assn

Tooth Loads. Gear Tooth Loads, E. Buckingham. Am. Mach., vol. 63, no. 20, Nov. 12 1925, pp. 783–785, 5 figs. Elementary treatment of various factors that enter into gear-tooth loads, such as torque, horsepower, pitch-line velocity.

GLUES

Evaluation. Recent Advances in Methods of Glue Evaluation, W. L. Jones. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 1072–1074, 3 figs. Difficulties presented by problem of glue testing; viscosity and jelly-strength tests, and standard methods for making them.

GRINDING

Centerless. Centerless Grinding. Mech. Eng., vol. 47, no. 11, Nov. 1925, pp. 943–946, 7 figs. "Through feed" and "in feed" methods of centerless grinding; increased production of pistons and piston pins obtained by use of centerless grinder; new theory on relation between control wheel, cutting wheel and work. Discussion of paper by W. J. Peets, published in Sept. issue of Journal.

Centreless Grinding, W. Ogilvie. Automobile Engr., vol. 15, no. 207, Oct. 1925, pp. 348–351, 6 figs. Outline of principles and notes on modern practice. (Abstract.) Paper presented before Instn. Production Engrs.

GRINDING MACHINES

Cam. A New Cam Grinding Machine. Automobile Engr., vol. 15, no. 207, Oct. 1925, p. 340, 2 figs. Describes multiple-wheel unit for high production.

Centerless. Coventry Centreless Grinding Machine, H. A. Dudgeon. Machy. (Lond.), vol. 27, no. 683, Oct. 29, 1925, pp. 144–146, 6 figs. Advantages of centerless grinder and description of No. 3 Coventry centerless grinder which is being applied to wide range of work.

Internal. "Omco" Internal Grinding Machine 12 x 10-Inch. Am. Mach., vol. 63, no. 20, Nov. 12, 1925, pp. 794–796, 4 figs. Produced by Oakmont Mfg. Co., Philadelphia, Pa., and intended for production grinding on internal surfaces that range between ½ in. and 12 in. in diam. and in length up to 10 in.

Production-Work. The Grinding Machine on Production Work, F. W. Curtis. Am. Mach., vol. 63, no. 21, Nov. 19, 1925, pp. 799–803, 13 figs. Improvement of abrasives and grinding machines; changing work designs to suit grinding practice; work adapted to grinding; various grinding operations.

GRINDING WHEELS

Failure. Some Causes of Wheel Failures, O. J. Lof. Abrasive Industry, vol. 6, no. 9, Sept. 1925, pp. 279–281. Explains causes of wheel accidents; a thorough investigation of each failure should be made as soon as possible.

H

HAMMERS

Drop. 5000-Lb. Four Roll Board Drop Hammer Built for Chrysler. Automotive Industries, vol. 53, no. 18, Oct. 29, 1925, pp. 752–753, 1 fig. First of this

type to be developed; used chiefly for making ring gears; product of Erie Foundry Co.

HANGARS

Airship. Concrete Airship Sheds at Orley, France, Freyssinet. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, nos. 332 and 333, Oct. 1925, 40 pp., 27 figs. on supp. plates, and 39 pp., 44 figs. on supp. plates. Part I: General aspect of problem of basic principles of final projects; principal structural elements. Part II: Supporting structure and method of moving mechanism for moving centering apparatus for handling materials; remarks on construction details. Translated from Genie Civil, Sept. 22, 29 and Oct. 1923.

HARDNESS

Testing. Hardness Testing of Hardened Steels (Die Härteprüfung von gehärteten Stählen), R. Mailänder. Stahl u. Eisen, vol. 45, no. 43, Oct. 22, 1925, pp. 1769–1773, 5 figs. Influence of hardness of balls employed in test; tests with diamond balls and cold-hardened steel balls; limits for accurate measurements; Meyer's law for hardened steels.

HEAT

Resistances. Heat Resistances (Die Wärmewiderstände), Wierz. Gesundheits-Ingenieur, vol. 48, no. 37, Sept. 12, 1925, pp. 457–460, 12 figs. Develops calculation of heat resistance in sense of electric resistance, temperature drop, etc., and its application to heat transmission in simple and compound walls, heat delivery of radiators in hot-water and in steam heating, heat transmission in heating boilers, etc.

Subterranean. Subterranean Heat. Mech. Eng., vol. 47, no. 12, Dec. 1925, pp. 1175–1178. Extracts of papers presented at Metropolitan Section mtg. of Am. Soc. Mech. Engrs., as follows: Subterranean Heat as a Source of Energy, L. P. Breckenridge; Internal Heat of the Earth, Geo. O. Smith; Developing Natural-Steam Wells at the Geysers, California, J. D. Galloway; Thermic Calculation of Subterranean Heat, Geo. A. Orrok; Comparative Study of the Various Forms of Volcanism as Sources of Power, F. A. Perret. See also Power, vol. 62, no. 21, Nov. 24, 1925, pp. 800–803, 5 figs.

HEAT TRANSMISSION

Heat Exchangers. Heat Exchangers (Die Einführung eines Formwertes bei Wärmetauschern), H. Preussler. Stahl u. Eisen, vol. 45, no. 41, Oct. 8, 1925, pp. 1705–1709. Relation of heat-carrier volume to construction design; calculation of design coefficient; load coefficient; features of heat carrier; importance of heat-absorption and heat-emission capacity; heat accumulators and air heaters.

HEATING

Buildings. Heating Buildings of Large Areas and High Roofs, W. W. Gaylord. Heat. & Vent. Mag., vol. 22, no. 10, Oct. 1925, pp. 66–68, 1 fig. Discussion with comparative installation and operating costs, using direct radiation in one case and unit heaters in other.

Heat Requirements, Determination of. Heat Requirements of Intermittently-Heated Buildings, W. Sommer. Heat. & Vent. Mag., vol. 22, no. 10, Oct. 1925, pp. 72–75, 7 figs. New graphic method of computation, for walls of any construction and for all outside and inside temperatures.

The Iso-Degree-Day Chart, P. E. Fansler. Heat. & Vent. Mag., vol. 22, no. 9, Sept. 1925, p. 73, chart on supp. page. New graphic method of showing heat requirements in any locality in United States and Canada. See also Iso-Gas-Consumption chart in Oct. 1925 issue, between pp. 82 and 83.

HEATING, HOT-WATER

England. English Method of Heating, L. J. Overton. Plumbers Trade Jl., vol. 79, nos. 7 and 8, Oct. 1 and 15, 1925, pp. 624, 624D and 626; and 720–722, 12 figs. Designing hot-water heating systems by B.t.u. method and figuring pipe sizes from friction charts, etc.

HEATING, HOUSE

Gas and Oil Combination, Use of. House-Heating by Combining the Use of Gas and Oil, H. O. Loebell. Heat. & Vent. Mag., vol. 22, no. 9, Sept. 1925, pp. 84–86, 1 fig. Characteristics which a desirable fuel for house heating should have; production of oil and its uses; gas best fuel, limited by price; characteristic house-heating load problem; application of degree-day; effect on gas load-factor of duplexing oil and gas fuel.

HEATING, STEAM

Central. Central Steam-Heating in Winnipeg, J. W. Sanger. Can. Inst. Min. & Metallurgy—Bul., no. 161, Sept. 1925, pp. 874–889, 1 fig. Central steam-heating system inaugurated in Winnipeg, October 1924; events which led up to proposal of central steam heating; notes on conditions favoring central heating in Winnipeg, preliminary estimates, location of steam plant, pipe estimates, conduits, pipe insulation, etc.; description of steam plant, with cost data, and losses.

Combined High-Pressure Power and Heating Plant, R. D. Dewolf. Power, vol. 62, no. 22, Dec. 1, 1925, pp. 828–831, 2 figs. At new plant of Rochester Gas & Elec. Corp., Rochester, N. Y., pulverized-coal boiler plant furnishes steam at 380 lb. per sq. in. to turbine exhausting into heating mains at pressures from 5 to 15-lb. per sq. in. gage, with supplementary live-steam service for heavy demands.

Halving Heating Costs with Central Station Steam, S. R. Lewis. Heat. & Vent. Mag., vol. 22, nos. 9 and 10, Sept. and Oct. 1925, pp. 82–83 and 49–59, 12 figs. Sept.: Reasons for adoption of central-station heating service in Masonic Temple at Springfield, Ohio, with detailed figures of savings effected thereby. Oct.: Describes heating and ventilating equipment for this building.

HYDRAULIC TURBINES

German Design. Modern Turbines Built by the Firm of F. Schichau (Neuere Turbinen von F. Schichau), H. Korn. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 45, Nov. 7, 1925, pp. 1397–1402, 20 figs. Large hydraulic turbines with spur gear, single-wheel turbines with barrel casing for hydro-electric plant at Töging on Inn River, Bavaria; results of tests.

Inspection. Compressed Air Used for Hydraulic-Turbine Inspection, C. R. Reid. Power, vol. 62, no. 19, Nov. 10, 1925, pp. 716–717, 1 fig. In La Gabelle power house of St. Maurice Power Co., Shawinigan Falls, Quebec, compressed air is used to lower tailwater in wheel chamber of 33,000-hp. turbines when inspections are to be made.

Isle Maligne Plant, Quebec. Erection of Turbines at Isle Maligne, C. M. Scudder. Can. Engr., vol. 49, no. 15, Oct. 13, 1925, pp. 449–452, 7 figs. Description of procedure followed in installation of twelve 45,000 hp. hydraulic turbines at Grande discharge for Duke-Price Power Co., Ltd.; fast time made under severe climatic conditions.

HYDROELECTRIC DEVELOPMENTS

Bonnington Falls, B. C. Power Plant at Lower Bonnington Falls. Contract Rec., vol. 39, no. 41, Oct. 14, 1925, pp. 992–994, 9 figs. Particulars of hydroelectric development recently completed by West Kootenay Power & Light Co., comprising three 20,000-hp. units; replaces an old 4000-hp. low-head plant.

Island Portage, Canada. Hydro-Electric Development at Island Portage. Can. Engr., vol. 49, no. 14, Oct. 6, 1925, pp. 429–431, 7 figs. General description of project on Abitibi River which will supply power to Hollinger Consolidated Gold Mines, Ltd., at Timmins, Ont.; two 12,000-hp. vertical turbines direct-connected to 12,000-kva. generators.

Niagara Falls Problems. Some Problems at Niagara Falls. Can. Engr., vol. 49, no. 18, Nov. 3, 1925, pp. 520–521, 1 fig. Horseshoe Falls receding in center; submerged dams would evenly distribute flow over crest and release more water for power purposes; proposal to take water from whirlpool rapids for power development.

Nova Scotia. Capital Costs of Sheet Harbor System, H. S. Johnston. Can. Engr., vol. 49, no. 18, Nov. 3, 1925, pp. 509–511, 4 figs. Further notes covering hydroelectric power developments of Nova Scotia Power Commission at Malay Falls and Ruth Falls; actual costs of both development and transmission line between Sheet Harbor and Pictou.

St. Lawrence River. Hydro Report on St. Lawrence River. Can. Engr., vol. 49, no. 12, Sept. 22, 1925, pp. 339–340. Abstract from statement and report by Hydro-Electric Power Commission of Ontario submitted to International Joint Commission together with supplementary information; report refers to three proposed schemes for power development.

Switzerland. Hydro-Electric Progress in Switzerland. Elec. Rev., vol. 97, no. 2498, Oct. 9, 1925, pp. 581–582, 5 figs. Some details of Amsteg (Uri) power station; barrage is located at Pfaffensprung, and impounds 200,000 cu. meters of water at an available head of 270 m.; turbines are of Pelton type, coupled direct to Oerlikon alternators, designed to work with water under a head of 902 ft. and a delivery of 1045 gal. per sec., running speed being 333⅓ r.p.m.

HYDROELECTRIC PLANTS

Dix River, Kentucky. Dix River Hydro-Electric Development, F. A. Dale. Elec. World, vol. 86, no. 19, Nov. 7, 1925, pp. 939–942, 7 figs. Existence of superpower system makes possible practically 100 per cent utilization of stream flow; plant designed for variation of head from 165 ft. to 235 ft.

Great Falls, Tennessee. Great Falls Plant Provides Peak Load Capacity, L. R. Lee. Power Plant Eng., vol. 29, no. 22, Nov. 15, 1925, pp. 1150–1151, 3 figs. Hydro plant of 30,000-kva. capacity is designed to tie in with steam plants; dam provides storage for dry periods.

Isle Maligne, Canada. Saguenay River Furnishes 540,000 Hp. Power Plant Eng., vol. 29, no. 18, Sept. 15, 1925, pp. 966–968, 8 figs. Isle Maligne hydro-electric plant near Lake St. John, containing twelve 45,000-hp. units, to be completed beginning of 1926; construction work electrical equipment.

Italy. The Power Plants on the Cenischia River of the Moncenisio Hydraulic Power Company (Gli impianti sul Cenischia della Società Forze Idrauliche del Moncenisio). Elettrotecnica, vol. 12, nos. 20, 21 and 22, July 15, 25 and Aug. 5, 1925, pp. 474–483, 501–511 and 526–537, 73 figs. Description of installations; two plants are in operation, Gran Scala and Venaus; that of Susa will be constructed in future; Gran Scala plant utilizes water fall of 196 m. and is provided with 2 generators of 1680 kva. each and one of 3000 kva.; static transformers transmit energy to Turin. Venaus plant utilizes waterfall of 1030 m. and is provided with 3 alternators, each of 21,200 kva. and 3 transformers.

Operation. Operating Practice in Hydro-Electric Plants, C. B. Hawley. Engrs. & Eng., vol. 42, no. 9, Sept. 1925, pp. 235–245, 4 figs. Discussion of some of the more important considerations governing selection and operation of hydroelectric machinery and accessory equipment; subject is treated from point of view of designing and operating engineers whose province is to select and assemble standard and special equipment available from manufacturer.

Seattle, Wash. Baker River Power Project Completed, W. A. Scot. Eng. Wld., vol. 27, no. 5, Nov. 1925, pp. 268–270, 2 figs. Details of Baker River hydroelectric project of Puget Sound Power & Light Co., Seattle; plant of 39,000-kva. capacity was placed in operation; concrete dam, upstream face of which is arched on a 250-ft. radius; pressure tunnel having length of 900 ft. between intake above dam and upper end of penstocks.

Semi-Automatic Operation. Semi-Automatic Operation for Small Hydro Plants, C. W. Geiger. Power Plant Eng., vol. 29, no. 21, Nov. 1, 1925, pp. 1106–1107, 5 figs. Installation of automatic equipment to convert manually operated plants into semi-automatic plants proves successful.

I

IMPACT TESTING

Notched-Bar Tests. The Effect of Temperature on the Behaviour of Iron and Steel in the Notched-Bar Impact Test, R. H. Greaves and J. A. Jones. Iron & Steel Inst.—advance paper, no. 9, for mtg. Sept. 1925, 40 pp., 27 figs. Results of study carried out by authors to determine influence of changes of atmospheric temperature on test, to investigate embrittling action of cold, and elucidate, if possible, features of blue brittleness of iron and steel, and temper brittleness of alloy steels. Bibliography. See also Engineering, vol. 120, no. 3121, Oct. 23, 1925, pp. 524–527, 23 figs.

Slow-Bend vs. Comparative Slow Bend and Impact Notched Bar Tests on Some Metals, S. N. Petrenko. Am. Soc. Steel Treating—Trans., vol. 8, no. 5, Nov. 1925, pp. 519–564, 26 figs. Results of tests to determine whether slow bend test may be used as substitute for, or as useful addition to, impact test; they were made in Izod pendulum-type impact machine 120 foot-pounds capacity and Humfrey slow-bend machine of 100 foot-pounds capacity, on cantilever beam-type specimens, having 10-by-10-mm. sections; slow-bend test gave values lower than impact for non-ferrous materials and higher than impact for steels; slow-bend is less convenient than impact test for ordinary routine practice. Bibliography.

INDICATORS

Diagram Converter. Indicator Diagrams, de Courcy. Automobile Engr., vol. 15, no. 207, Oct. 1925, pp. 334–335, 5 figs. Instrument for converting from time-pressure to stroke-pressure basis.

INDUSTRIAL MANAGEMENT

Planning Department. A Planning Department—for What? Automotive Industries, vol. 53, no. 18, Oct. 29, 1925, pp. 734–736. If only for production, without taking into equal account such important factors as market conditions and sales possibilities, its value is apt to be small; sales and production must be planned together.

Production, Analyzing for. Analyzing for Production, W. B. Gardiner. Am. Mach., vol. 63, no. 22, Nov. 26, 1925, p. 852, 2 figs. To analyze for production is to make complete study of all of details employed in manufacturing, factory methods, cost and production systems and methods of applying and handling them.

Psychology in Industry. The Present State of Industrial Psychology, Lillian M. Gilbreth. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 1039–1042. Consideration of science and art of handling men, and evaluation of successes and failures that are found.

Sales Organization. Liquid Carbonic Sales Organization, W. J. Graham. Mgmt. & Admin., vol. 10, no. 5, Nov. 1925, pp. 255–258. Organization of sales department of Liquid Carbonic Co.; territorial organization; general sales manager; assistant sales manager; special sales executives; branch manager; sales research and planning; classes of customers, orders, and terms; sales information manual; sales conventions; contests among salesmen and branches.

Simplification. Are There Any Real Obstacles to Simplification? R. M. Hudson. Factory, vol. 35, no. 4, Oct. 1925, pp. 537–538, 586, 588 and 590. These obstacles are discussed under heads of antipathy to government, fear of government regulation or control, fear of prosecution, lack of coöperative spirit.

Small Factories. Capitalizing the Advantages of the Small Factory, D. S. Cole. Indus. Mgmt. (N. Y.), vol. 70, no. 5, Nov. 1925, pp. 265–269. Author points out fallacy for small factory of succumbing to lure of large order.

Making a Success of the Small Manufacturing Business, C. U. Carpenter. Mgmt. & Admin., vol. 10, nos. 3, 4 and 5, Sept., Oct. and Nov. 1925, pp. 125–128, 195–198 and 287–289. Sept.: How to get through early stages. Oct.: How to run shop. Nov.: How to sell product.

Woodworking Plants. Organization for Production and Profit, C. F. Scribner. Wood-Worker, vol. 44, no. 7, Sept. 1925, pp. 42–45, 4 figs. Describes how "Gantt" charts have been profitably applied to management and operation of wood-working plants.

INDUSTRIAL PLANTS

Design. Influence of Plant Design on Plant Efficiency, H. T. Moore. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 1059–1060. Economical selection of industrial site; basic data which determine plant design; site limitations which affect plant layout; design of plant.

Electric-Power Costs. Electrical Power Costs, D. Ross-Ross. Mgmt. & Admin., vol. 10, no. 5, Nov. 1925, pp. 285–286, 4 figs. Analysis of how to avoid maximum demand charges.

Steam-Costs Control. The Executive Control of Steam Costs, F. M. Gibson. Indus. Mgmt. (N. Y.), vol. 70, no. 6, Dec. 1925, pp. 346–350, 2 figs. Points out need for accuracy; ratio of input to output; fuel values in heat units; periodic check-up of heat balance; cost records a function of cost-accounting department; operating and repair costs; overhead expense; fixed charges; small power plant.

INSPECTION

Automobile Industry. Production Equipment for Inspection, W. E. Irish. Am. Mach., vol. 63, no. 19, Nov. 5, 1925, pp. 735–737, 5 figs. Speeding up inspection in automobile industry; inspecting chassis frames on layout table; checking up jigs and fixtures with table.

INTERNAL-COMBUSTION ENGINES

Michell Crankless. The Michell Crankless Engine. Automobile Engr., vol. 15, no. 207, Oct. 1925, pp. 316–320, 13 figs. New form of high-speed multicylinder engine which, by radical novelty of its construction, evades several of most serious difficulties confronting designers of conventional type of engine; new design is in perfect dynamic balance.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; GAS ENGINES; OIL ENGINES.]

IRON

Desulphurization of. Desulphurization of Ferrous Metals, Geo. A. Drysdale. Am. Foundrymen's Assn.—advance paper, no. 463, for mtg. Oct. 5–9, 1925, 10 pp. Author states that in dealing with ferrous metals, good deal of trouble encountered is caused by action of sulphur and oxides when metal is poured into mold and while it is setting; action of sulphur on cast iron is very detrimental, causing excessive shrinkage, hardness, porosity, and blowholes; effect of using sodium compound as desulphurizer and purifier, in melting of high-sulphur iron, produces softer iron and eliminates hard spots, excessive shrinkage, porosity and sulphur scab; resulting castings tend to give higher physical properties and lower Brinell hardness; use of sodium compound as flux; results of experiments.

IRON AND STEEL

Electrolytic Corrosion. The Electrolytic Corrosion of Ferrous Metals, W. M. Thornton and J. A. Harle. Faraday Soc.—Trans., vol. 21, part 1, no. 61, Aug. 1925, pp. 23–32 and (discussion) 32–35, 4 figs. From experimental results, conclusion is reached that not only have pure metals definite rates of corrosion according to Faraday's law of electrolysis, but that every ferrous alloy examined has specific rate of electrolytic corrosion by which it can be identified with certainty.

Hardness. The Influence of Strain and of Heat on the Hardness of Iron and Steel, A. Saveur and D. C. Lee. Iron & Steel Inst.—advance paper, no. 18, for mtg. Sept. 1925, 7 pp., 4 figs. Experiments show that on heating normalized iron and steel above atmospheric temperature their strength and hardness are at first slightly decreased, this being followed by increase which reaches its maximum in blue-heat range of temperature; straining normalized iron or steel above their elastic limit increases both strength and hardness; hardness resulting from cold deformation at room temperature is increased further by heating metal above atmospheric temperature.

IRON CASTINGS

Cleaning. Reducing the Cost of Cleaning Ferrous Castings, J. H. Hopp. Am. Foundrymen's Assn.—advance paper, no. 468, for mtg. Oct. 5–9, 1925, 11 figs. Discusses factors of shop practice which affect cleaning operation; molding sand together with use of facing is stated to be one of factors which needs most careful attention; proper placing of gates and risers and composition of cores are discussed as factors which must be considered in advance of production of casting; author believes that more castings are lost from use of risers than from failure to use them; points out desirability of studying bonds of grinding wheels.

Design. Metallurgical Points on Casting Design, F. C. Edwards. Metal Industry (Lond.), vol. 27, no. 16, Oct. 16, 1925, pp. 365–367, 6 figs. Influence of size of section on strength of cast iron; thickness of section and size of graphite; differential shrinkage; points out typical case in historic example of failure of hydraulic cylinder during building of Menai bridge; shrinkage more important than crystal structure at sharp corners; reinforcing cast-iron section.

Test Control. New Methods in the Test Control of Castings, M. Thomas. Metal Industry (Lond.), vol. 27, no. 19, Nov. 6, 1925, pp. 439–440. Reference is made to tests carried out on certain irons, as result of which fairly definite relations were established between their various properties, and this data used as means by which simple yet rigorous method of quality control of production of large French marine engineering foundry has been established. Abridged translation of paper presented before Franco-Belgian Foundry Congress.

L

LATHES

Automobile. Herbert No. 5 Auto-Lathe at the Motor Exhibition, Olympia. Mach. (Lond.), vol. 27, no. 681, Oct. 15, 1925, pp. 73–74, 3 figs. Machine, which is entirely automatic in operation, has been improved by several alterations; headstock is more powerful, driving pulley running 50 per cent faster; change-gear casings on headstock are more accessible and positive safety interlock is provided.

Turret. Elliptical Turret Lathe Operations, Chas. O. Herb. Machy. (N. Y.), vol. 32, no. 3, Nov. 1925, pp. 180–181, 7 figs. Describes machines and tooling equipments built by Warner & Swasey Co., Cleveland, Ohio.

LIQUIDS

Characteristic Curves of Jets. The Characteristics Curves of Liquid Jets, E. Tyler and E. G. Richardson. Physical Soc. Lond.—Proc., vol. 37, part 5, Aug. 15, 1925, pp. 297–311, 10 figs. Continuing work of S. W. J. Smith and H. Moss upon relation between length of capillary jet and its velocity of efflux from cylindrical orifice, further examination has been made of causes to which main features of curves obtained by these authors are due; results indicate that, while surface tension is of prime importance in first parts of these curves, viscosity is dominating factor in second.

Viscosity at Boiling Point. On the Viscosities of Liquids at Their Boiling-Points, D. B. Macleod. Faraday Soc.—Trans., vol. 21, part 1, no. 61, Aug. 1925, pp. 160–167. Concludes that boiling points are unsatisfactory temperatures at which to compare viscosities of liquids; by correcting boiling points to condition of equal free space, viscosities of liquids become proportional to their molecular weights in liquid state.

LOCOMOTIVES

Coaling Plants. Locomotive Coaling Plant: Latest German Practice, H. Koblenz. Indus. Mgmt. (Lond.), vol. 12, no. 10, Oct. 1925, pp. 474–476 and 486, 12 figs. Chief requirements that a locomotive coaling plant should fulfill; describes development of German system.

Diesel-Engined. The Baden Diesel Locomotive (Die "Baden"-Motor-Lokomotive). Motorwagen, vol. 28, no. 22, Aug. 10, 1925, pp. 480–481, 4 figs. Locomotive contains hydraulic transmission in successful commercial service; transmissions consist of vane pump and vane engine; speed is changed by connecting in a varying number of compartments in pump.

Draft Arrangements. Drafting Locomotives for Efficiency and Economy in Fuels. Ry. & Locomotive Eng., vol. 38, no. 10, Oct. 1925, pp. 287–290, 3 figs. Discusses methods of draft arrangements; amount of air to be admitted. Report of Committee presented to Traveling Engrs.' Assn.

Driving-Box Practice. How Driving-Box-Practice Varies, F. C. Hudson. Am. Mach., vol. 63, no. 18, Oct. 29, 1925, pp. 697–699, 10 figs. Details of driving-box design from number of well-known railroads, showing methods of applying hub and shoe and wedge liners.

Feedwater Treatment. Treated Water Increases Locomotive Efficiency, R. C. Bardwell. Ry. Rev., vol. 77, no. 18, Oct. 31, 1925, pp. 669–671. Notes on scale pitting and foaming; boiler compounds, soda-ash treatment, zeolite, lime-soda plant, and continuous plants; savings effected by treatment. Paper presented at Am. Ry. Bridge & Bldg. Assn.

Garratt. Developments in British Locomotives, G. P. Blackall. Boiler Maker, vol. 24, no. 10, Oct. 1925, pp. 297–299, 3 figs. Particulars of Garratt-type 6-cylinder locomotive developing tractive force of 72,940 lb. at 85-per cent boiler pressure, and of Mikado 2-8-2-type 3-cylinder locomotive whose main cylinders develop tractive effort of 38,500 lb. at 85-per cent boiler pressure, both of London and North Eastern Ry.

Heavy Freight. A New Development in American Locomotive Practice. Ry. Engr., vol. 46, no. 549, Oct. 1925, pp. 345–349, 15 figs. Interesting features incorporated in design of 2-8-4-type heavy freight locomotive, and particulars; built by Lima Locomotive Works.

Single-Expansion Articulated. Simple Articulated Locomotives for G. N. Ry., W. W. Baxter. Ry. Rev., vol. 77, no. 17, Oct. 24, 1925, pp. 629–634, 8 figs. Four of most powerful single-expansion freight engines ever built by Baldwin placed in service on Great Northern.

Stokers for. See STOKERS, LOCOMOTIVE.

Switching. P. R. R. Limited Cut-Off Switch Engines, W. W. Baxter. Ry. Rev., vol. 77, no. 20, Nov. 14, 1925, pp. 733–736, 7 figs. Unusually large 8-wheel locomotive having many interesting features built for yard service.

Testing Plant. The Locomotive Testing Plant and Its Influence on Steam-Locomotive Design, L. H. Fry. Mech. Eng., vol. 47, no. 11, Nov. 1925, pp. 881–886, 7 figs. Brief history of locomotive testing plants and their contributions to development of locomotive; work done by Altoona testing plant; contrasts of size and economy of locomotives made 20 years ago and at present time. (Abridged.) See also Ry. Age, vol. 79, no. 17, Oct. 24, 1925, pp. 752–755, 3 figs.

LOGGING

Machinery for. Logging Machinery Used on the Pacific Coast, Wm. C. Shaw. Mech. Eng., vol. 47, no. 11, Nov. 1925, pp. 913–914, 1 fig. Notes on steam engines, frames, gears and drums, boilers and Diesel engines.

LUBRICANTS

Grease. Lubricating Grease, G. B. Vroom. Am. Soc. Naval Engrs.—Jl., vol. 37, no. 3, Aug. 1925, pp. 551–559, 4 figs. Discusses consistency, flow point, characteristics of contained oil, and freedom from impurities and fillers; determination, by experimental laboratory data, of behavior of greases made up to conform to known operating conditions, in respect to bearing temperature and pressure, and temperatures of cups, both gravity and continuous feed types; answers to objection that placing grease on a scientific footing would result in an increase of costs.

LUBRICATING OILS

Density at Low Temperatures. Density of a Lubricating Oil at Temperatures from −40° to +20° C., H. K. Griffin. Indus. & Eng. Chem., vol. 17, no. 11, Nov. 1925, pp. 1157–1158, 2 figs. Properties of oil; filling pycnometer; experimental procedure.

Filter for Recovery of. The Steam-Line Oil Filter. Petroleum Times, vol. 14, no. 351, Sept. 26, 1925, pp. 535–536, 2 figs. Describes invention by H. S. Hele-Shaw for recovery of used lubricating oils.

LUBRICATION

Problems. Lubricants and Lubricating, Jas. Duguid. Mech. Eng., vol. 47, no. 11, Nov. 1925, pp. 887–894. Supply of lubricating oils; theory of lubrication; cylinder oils; lubrication of cylindrical bearings; bearing loads and temperatures; application of lubricants to bearings; power losses; packing waste; reclamation of used packing and oil; cost of lubrication. (Abridged.)

M

MACHINE DESIGN

Analysis of Problems. The Question of Mark in Machine Design, F. E. Cardullo. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 1009–1011, 3 figs. Difficulties encountered in analysis of design problems that call for exercise of judgment; loose thinking and its probable effects on engineering design; false impressions current with regard to design of machine foundations, bearings, open-side machine frames, etc.

MACHINE SHOPS

Routing Work. Routing Work in a Machine Tool Plant, A. L. Baker. Machy. (N. Y.), vol. 32, no. 3, Nov. 1925, pp. 175–178, 7 figs. Production system adopted by machine-tool builder after study of systems employed in number of shops.

U. S. Post-Office Department. Making Locks for the U. S. Mails. Iron Age, vol. 116, no. 19, Nov. 5, 1925, pp. 1249–1250, 1 fig. Producing 8000 locks per day to protect mails in transit; other products of post-office department shops.

MACHINE TOOLS

Arrangement for Processing Parts. Machine-Tool Arrangement for Processing Parts, H. H. Edge. Am. Mach., vol. 63, no. 20, Nov. 12, 1925, pp. 759–761, 10 figs. Successful operating plan that provides for dividing parts to be machined into two classes, round work and flat work.

Gear-Running Machines. Parkinson Gear Running Machine. British Mach. Tool Eng., vol. 3, no. 35, July-Aug. 1925, pp. 288–289, 1 fig. Description of machine produced by J. Parkinson & Son, Shipley, England, for production of gears that must run as noiselessly as possible and transmit power with a high efficiency.

Multiple-Spindle Automatics. Multiple-Spindle Automatics, Jos. Horner. Engineering, vol. 120, nos. 3105, 3108, 3111, 3118 and 3124, July 3, July 24, Aug. 14, Oct. 2 and Nov. 13, 1925, pp. 3–7, 93–97, 187–190, 405–407 and 597–601, 77 figs. Deals with application of multiple-spindle work to revolving work head or turret head equipped usually with from 4 to 6 spindles; Gridley automatic; machines by New Britain Machine Co., New Britain, Conn. Oct. 2. Goss and De Leeuw multi-spindle automatic machines. Nov. 13: Type with spindles arranged vertically.

Puncher-Slotters. The Butler Puncher-Slotter. Mech. Wld., vol. 78, no. 2020, Sept. 18, 1925, pp. 219–220, 3 figs. Describes heavy-duty machine manufactured by Butler Machine Tool Co., Ltd., Victoria Ironworks, Halifax; developed to provide a simple, robust type of machine capable of effecting considerable economies in heavy forging work by rapid yet accurate removal of metal, thus greatly reducing amount of forging necessary.

Replacement Policy. Getting the Most Out of Your Machine Tool Dollar, Wm. Bailey. Am. Mach., vol. 63, no. 24, Dec. 10, 1925, pp. 917–920. Practice followed by Hoover Co. in selection, selling, and junking machine tools.

MACHINING METHODS

Number of Parts to Make at One Set-up. The Most Economical Number of Parts to Make at One Set-up, J. M. Christman. Machy. (N. Y.), vol. 32, no. 3, Nov. 1925, pp. 182–183, 1 fig. Presents chart for determining most economical number.

MALLEABLE IRON

Annealing. A Consideration of the Annealing Operation in the Malleable Foundry, C. J. McNamara and C. H. Lorig. Am. Foundrymen's Assn.—advance paper, no. 466, for mtg. Oct. 5–9, 1925, 11 pp., 14 figs. Results of data secured by experiments which were carried out with object of obtaining knowledge of rate at which iron graphitizes; continued slow cooling below critical point is said to be of little purpose in producing good malleable iron; specimens quenched in water from temperature just below critical range were as ductile as those which were allowed to cool in furnace; excessive oxidation of annealing pots is one real disadvantage resulting from opening annealing oven at too high a temperature.

Blackheart. Electrically-Produced Blackheart Malleable, F. A. Melmoth. Foundry Trade Jl., vol. 32, no. 478, Oct. 15, 1925, pp. 325–328; and (discussion) no. 479, Oct. 22, 1925, pp 351–355, 5 figs. Influence of composition; potentialities of electrically made malleable; packing material; heat conduction through boxes; furnace design; annealing process; defects due to annealing; banding; physical tests results.

Rapid Annealing. The Effects of Some Modifications of a Rapid Annealing Method on the Physical Properties of Malleable Iron, A. Hayes, E. L. Henderson and G. R. Bessmer. Am. Foundrymen's Assn.—advance paper, no. 481, Oct. 5–9, 1925, pp. 6–11, 9 figs. Preliminary report of careful study being made of influences of modification of various rapid methods of annealing upon physical properties of product: results of authors' investigations lead to conclusion that any annealing method which produces small grain structure and well rounded carbon spots, and which results in complete graphitization, will duplicate physical

properties of malleable iron produced by present commercial methods; such properties can be duplicated in annealing periods of 40 hours or less.

MANGANESE STEEL

Heat Treatment, Effect on. Certain Unsolved Problems Relating to Manganese Steel, Rob. Hadfield. Chem. & Industry, vol. 44, no. 43, Oct. 23, 1925, pp. 1042–1044, 4 figs. Effect of heat treatment on hardness and magnetic character; photomicrographic examination.

MATERIALS HANDLING

Factories. Adapting Handling Methods to Plant Expansion. Indus. Mgmt. (N. Y.), vol. 70, no. 2, Aug. 1925, pp. 77–82, 14 figs. Methods and equipment of the Chapman Valve Mfg. Co.; problem, from materials-handling standpoint, lay in fitting system into existing buildings, with eye also to future expansion.

Handling Diverse Products through Many Operations. Indus. Mgmt. (N. Y.), vol. 70, no. 2, Aug. 1925, pp. 73–76, 10 figs. Problems, methods and equipment of plant of Fuller Brush Co., manufacturers of household mops, dusters, brushes and brooms.

Machine-Tool Plant. Handling under Difficulties. Indus. Mgmt. (N. Y.), vol. 70, no. 2, Aug. 1925, pp. 67–72, 14 figs. Problems, methods and equipment of plant of Brown & Sharpe Mfg. Co.

Multi-Storied Buildings. Materials Handling in Multi-Storied Buildings. Indus. Mgmt. (N. Y.), vol. 70, no. 2, Aug. 1925, pp. 83–88, 10 figs. Problems of Crompton & Knowles Loom Works.

Problems. Materials-Handling Problems and Their Solution, F. D. Campbell. Mech. Eng., vol. 47, no. 11a, Mid-November, 1925, pp. 973–978, 9 figs. Deals with problems of movement of products in industrial plants, whether goods are being received or are going through various processes of operation, distribution, assembly, collection, packing, storage and shipment, and application of mechanical means to effect such movement.

Soap Factory. Materials Handling and the Price of Soap. Indus. Mgmt. (N. Y.), vol. 70, no. 2, Aug. 1925, pp. 109–115, 18 figs. Handling methods and equipment at Port Ivory, Staten Island.

Transferring, Without. Handling without Transferring, M. W. Potts. Indus. Mgmt. (N. Y.), vol. 70, no. 5, Nov. 1925, pp. 296–300, 10 figs. Systems which do away with unnecessary rehandling.

Westinghouse Plant, East Pittsburgh. A Typical Big Plant with Variety of Products. Indus. Mgmt. (N. Y.), vol. 70, no. 2, Aug. 1925, pp. 89–95, 19 figs. How Westinghouse Elec. & Mfg. Co. handles materials at East Pittsburgh.

MEASUREMENTS

Bibliography. Literature on Measuring. Eng. Progress, vol. 6, no. 9, Sept. 1925, pp. 307–308. Bibliography of general articles; length and capacity measuring; time measurement; pressures, velocities, etc.; mechanical properties and composition of bodies; heat measurements; electric and magnetic measurements; optical and acoustic measurements.

Precision. Precision Measurements, G. Berndt. Eng. Progress, vol. 6, no 9, Sept. 1925, pp. 289–291, 4 figs. Their significance and utility in engineering; examples taken from machine construction and instrument making, illustrating great savings achieved by applying precision measuring. (Abstract.) Lecture presented before Cologne Mtg. on Measuring Instruments.

MEASURING INSTRUMENTS

Optical. Optics as Applied to Measuring, O. Eppenstein. Eng. Progress, vol. 6, no. 9, Sept. 1925, pp. 293–301, 23 figs. Applications in construction of apparatus and machines; notes on magnifying glass; optical dividing head; measuring microscope; projecting apparatus; thread-measuring comparator; micrometer; optimeter; measuring machine; measuring by light interference.

Principles and Advantages of Optical Methods for Measuring Machine Parts, H. F. Kurtz. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 987–992, 16 figs. Outlines four classes of optical instruments, namely, interference apparatus, imaging systems, optical scale reading and optical levers; and describes measuring instruments already designed for machine-measuring purposes.

MECHANISMS

Geneva-Stop Analysis. Graphical Analysis of the Geneva Stop, C. M. Conradson. Machy. (N. Y.), vol. 32, no. 3, Nov. 1925, pp. 212–214, 9 figs. Analysis presented with view to making study of this mechanism easier; it is shown that pair of imaginary arms connected by imaginary link can be substituted for Geneva stop mechanism and be kinematically identical with it.

METALS

Fatigue Tests. High-Frequency Fatigue Tests. Metallurgist (Supp. to Engineer, vol. 140, no. 3644), Oct. 30, 1925, pp. 145–146. Review of account by C. F. Jenkin, of Oxford, of series of tests at very high speeds; he has succeeded in reaching 2000 alternations per second in oscillatory bending test.

X-Ray Examination. New X-Ray Studies of the Ultimate Structures of Commercial Metals, Geo. L. Clark, E. W. Brugmann, and S. D. Heath. Indus. & Eng. Chem., vol. 17, no. 11, Nov. 1925, pp. 1142–1146, 17 figs. Presents monochromatic pinhole method as most fruitful for utilizing X-rays in practical identification of working and heat-treating processes in metals; reproduces representative X-ray photographic diagrams for metals with different properties, to show great possibilities of obtaining purely scientific information, of fundamentally relating physical properties with ultimate structures, and of controlling and perfecting manufacturing technique by this method.

MILLING

Turbine Blades. Milling Turbine Impulse Blades Machy. (N. Y.), vol. 32, no. 3, Nov. 1925, pp. 220–221, 5 figs. Describes milling operations in turbine-blade department of Westinghouse Elec. & Mfg. Co.'s South Philadelphia Works.

MOLDING MACHINES

Electric. The Electric Molder, A. Jensen, Jr. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 984–986, 4 figs. Analysis of its power requirements and production possibilities in woodworking, and comparison with belt-driven molder.

Jarring. New Foundry Machines (Neue Giessereimaschinen), Hammers. Zeit. für die gesamte Giessereipraxis, vol. 46, no. 34, Aug. 23, 1925, pp. 408–413, 9 figs. Describes improvements in jarring machines; and enumerates advantages of newest design.

MOLDS

Semi-Permanent. Semi-Permanent Molds, E. D. Gleason. Metal Industry (N. Y.), vol. 23, no. 10, Oct. 1925, pp. 411–412, 6 figs. Discussion of various compositions and methods of molding.

MOTOR BUSES

Albion. Albion 1926 Passenger Models. Motor Transport (Lond.), vol. 41, no. 1076, Oct. 12, 1925, pp. 429–431, 6 figs. First particulars of two omnibus and two coach chassis complying with proposed constructional regulations for hackney vehicles; 4-cylinder engine 20.7 hp. R.A.C. rating.

Caledon. A New Caledon Motor Transport (Lond.), vol. 41, no. 1076, Oct. 12, 1925, pp. 438–440, 6 figs. A pneumatic four-wheel braked chassis with alternative long or short wheelbase for passengers or goods; four-cylinder engine 24.7 hp. R.A.C. rating.

Karrier Low-Level. British Bus Chassis Has U-Shaped Frame Dip under Rear Axle, M. W. Bourdon. Automotive Industries, vol. 53, no. 18, Oct. 29, 1925, p. 754, 2 figs. Novel design gives low floor level; down-sweep of side members staggered at front; developed by Karrier Motors.

Maudslay. A New Maudslay 'Bus. Motor Transport (Lond.), vol. 41, no. 1075, Oct. 5, 1925, pp. 399–402, 9 figs. Comfort and safety for passenger, reliable and economical running for operator, claimed to be combined characteristics of latest range of public service vehicles recently introduced by Maudslay Motor Co., Ltd., Coventry, Eng.; covered top-decker; 4-cylinder engine with 36.15 hp. R.A.C. rating.

MOTOR TRUCKS

Dennis. A 30-cwt. Dennis. Motor Transport (Lond.), vol. 41, no. 1077, Oct. 19, 1925, pp. 481–483, 9 figs. Low first cost, simplicity in design and ease of upkeep characterize entirely new chassis; four-cylinder engine with 18–21 hp. R.A.C. rating.

Electric. The Olympia Show. Motor Transport (Lond.), vol. 41, no. 1079, Nov. 2, 1925, pp. 583–584, 5 figs. Brief description of electric vehicles at Seventh International Commercial Motor Transport Exhibition.

Halley. A Halley Subsidy Model. Motor Transport (Lond.), vol. 41, no. 1080, Nov. 9, 1925, pp. 639–641, 8 figs. Describes vehicle built by Halley Industrial Motors, Ltd., to conform to War Dept.'s Subsidy Specification for 30-cwt. vehicles; accessibility and ease of maintenance in chassis introducing a flexibly mounted unit construction with central change lever.

McCurd. The New McCurd 2-Tonner. Motor Transport (Lond.), vol. 41, no. 1078, Oct. 26, 1925, pp. 525–526, 7 figs. Pneumatic-tired four-wheel braked chassis; 4-cylinder engine, 25 hp. R.A.C. rating.

Olympia Show. The Olympia Show. Motor Transport (Lond.), vol. 41, no. 1079, Nov. 2, 1925, pp. 558-582, 89 figs. A stand-to-stand survey, alphabetically arranged, of gasoline and gasoline-electric vehicle exhibits at Seventh International Commercial Motor Transport Exhibition.

Star. The Star 2-Tonner. Motor Transport (Lond.), vol. 41, no. 1076, Oct. 12, 1925, pp. 433–434, 3 figs. First details of a new chassis built for economical working; four-cylinder engine 20.1 R.A.C. rating; front-wheel brakes optional.

Steam. The Olympia Show. Motor Transport (Lond.), vol. 41, no. 1079, Nov. 2, 1925, pp. 585–587, 12 figs. Brief description of steam vehicle exhibits at Seventh International Commercial Motor Transport Exhibition.

Trailers. The Olympia Show. Motor Transport (Lond.), vol. 41, no. 1079, Nov. 2, 1925, pp. 595–596, 7 figs. Brief description of trailer exhibits at Seventh International Commercial Motor Transport Exhibition; 2- and 4-wheelers for variety of purposes.

Transmission Case, Machining. Machining the Transmission Case of the Mack Truck and Bus, F. W. Curtis. Am. Mach., vol. 63, nos. 19 and 20, Nov. 5 and 12, 1925, pp. 729–733 and 765–768, 26 figs. Nov. 5: Inspection of rough castings; limits of accuracy required; variety of milling operations; boring of shaft holes in one setting; unusual types of trunnion jigs. Nov. 12: Method of driving studs; forming selector-shaft holes; rigid inspection methods employed; machining operations for top cover.

N

NON-FERROUS METALS

Deoxidizers for. Deoxidizing Processes and Deoxidizers in the Melting of Non-Ferrous Metals (Die Desoxydationsvorgänge und die Desoxydationsmittel der Nichteisenmetallschmelzen), W. Claus. Giesserei-Zeitung, vol. 22, no. 18, Sept. 15, 1925, pp. 557–565. Physical and chemical constants of deoxidizers; oxide formation in connection with pouring of metal; deoxidation of molten bath of heavy and of light metal alloys; removal of aluminum from molten bath of copper-base alloys by means of oxidation process; technical deoxidizers and rules for their selection.

Endurance Properties. Endurance Properties of Non-ferrous Metals, D. J. McAdam, Jr. Am. Inst. Min. & Met. Engrs.—Trans., no. 1506-E, Oct. 1925, 22 pp., 14 figs. Typical stress-cycle graphs for non-ferrous metals as obtained at Naval Engineering Experiment Station, University of Illinois, and McCook Field; form of stress-cycle graph; possible reasons for abnormal graphs for some non-ferrous metal obtained at University of Illinois and at McCook Field. Bibliography.

Melting, Atomized-Coal System of. Atomized Coal System of Non-Ferrous Melting, R. Black and C. L. Shafer. Am. Foundrymen's Assn.—advance paper, no. 472, for mtg. Oct. 5–9, 1925, 7 pp. Atomized coal system is name applied to use of specially prepared bituminous coal for melting non-ferrous metal which, so far has been applied only to crucible melting; describes preparation of coal, and method and equipment used in burning; it is stated that theory of burning as worked out for pulverized coal does not hold good for atomized coal as related to requirements of combustion; for atomized coal, air supply and combustion space in experimental work has been steadily diminished; costs of atomizing coal and of melting with it are given.

Temperature Determination. The Temperature Determination of Non-Ferrous Alloys, R. L. Binney. Am. Foundrymen's Assn.—advance paper, no. 470, for mtg. Oct. 5–9, 1925, 11 pp. Discusses points brought out in author's study of temperature control; types of devices investigated were optical, radiation, base-metal pyrometers, temperature cones, potentiometer vs. high- and low-resistance meters and combinations of these methods.

O

OIL ENGINES

Cylinder Wear Due to Dirty Fuel. How Dirty Fuel May Damage Oil-Engine Cylinders, A. B. Newell. Power, vol. 62, no. 17, Oct. 27, 1925, pp. 644–645. Points out that engines burning dirty fuel always show abnormal cylinder wear, thus wear ultimately is traceable to foreign substances; absence of abnormal wear at lower end of cylinder indicates that abrasive in fuel is not directly causing trouble; better lubrication needed.

Solid-Injection. Three-Cylinder 225-H.P. Worthington Two-Cycle Oil Engine. Engineering, vol. 120, no. 3124, Nov. 13, 1925, pp. 605–606, 12 figs. partly on supp. plate. Principle of action and construction details of solid-injection type manufactured by Worthington-Simpson, London.

OIL FUEL

Burners. Some Hints on Installing and Operating Domestic Oil Burners, C. H. Chalmers. Am. Soc. Heat. & Vent. Engrs.—Jl., vol. 31, no. 10, Oct. 1925, pp. 471–475, 1 fig. Notes on oil storage, and subbasement tank; U. S. Government recommendations on boiler and furnace design for oil burners.

The Filam Oil Burner. Petroleum Times, vol. 14, no. 347, Aug. 29, 1925, pp. 365–366, 2 figs. Simplified oil-firing device in which complete atomization of fuel at low velocity has been perfected in such manner that there is correct combustion, resulting in flame of high temperature, short length and soft diffusion.

OXY-ACETYLENE WELDING

Pipe Lines. Welding City Pipe Lines, E. E. Lungren. Gas Industry (Mfrd. Gas Edition), vol. 25, no. 8, Aug. 1925, pp. 285–290, 5 figs. Discusses use of oxy-acetylene welding in city lines service. Welding pipe joints ends gas leak troubles; preventing breaks from contraction stresses; comparative installation costs; uses of blowpipe in gas industry.

P

PACKING

Shipping Containers. Scientifically Developed Shipping Containers, C. M. Bonnell, Jr. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 979–983, 7 figs. Yearly cost of packing and shipping commodities; classification of commodities; standardization of lumber for containers; wooden boxes, crates, barrels, and casks; tests on containers; loading and bracing containers in cars.

PAINTS

Testing. Testing Paint by the Removed Film Method. Ry. Mech. Engr., vol. 99, no. 11, Nov. 1925, pp. 693–697, 4 figs. Presence of inferior bases and reducing oils can be easily determined; tests of new stock prevent waste. Abstracts of paper by W. O. Quest, and committee report before Am. Ry. Assn.

PLANERS

Double-Housing. New Double-Housing Planer. Iron Age, vol. 116, no. 18, Oct. 29, 1925, pp. 1186–1188, 5 figs. Feed and traverse of heads and movements of cross-rail accomplished by means of motor or rail; pendant switch facilitates operation; rapid clamping.

Gear. 14-inch Spiral Bevel Gear Planer. Machy. (Lond.), vol. 27, no. 684, Nov. 5, 1925, pp. 171–173, 5 figs. New machine by Alfred Herbert, Coventry, suitable for cutting all standard tooth pitches up to and including 5-diametrical, or equivalent, in circular or module pitch, and is notable for simplicity and convenience with which it can be set and operated.

Niles-Bement-Pond. Niles-Bement-Pond Planers. Machy. (N. Y.), vol. 32, no. 3, Nov. 1925, pp. 239–241, 4 figs. Design embodies various new features, such as complete control of tool slides, cross rail, side heads, and table movement from pendent switch, as well as by mechanical means, etc.

Variable-Voltage Reversing Drive. Variable-voltage Reversing Planer Drive, A. L. Harvey. Machy. (N. Y.), vol. 32, no. 3, Nov. 1925, pp. 215–216, 1 fig. Enumerates advantages of variable-voltage equipment; describes Westinghouse planer equipment, which consists of reversing planer motor, motor-generator set, panel for field-reversing contactors, field rheostats to obtain proper speed on cutting and return strokes, etc.; comparison of constant-voltage and variable-voltage drives.

POWER

Power Show, New York City. Fourth Annual Power Show Has Many New Features. Power, vol. 62, no. 22 and 23, Dec. 1 and 8, 1925, pp. 852–857 and 895–906, 13 figs. Outstanding features of exhibition. Dec. 1: Alphabetical list of exhibitors and their products. Dec. 8: Details of exhibits of steam turbines, pulverized-coal equipment, centralized systems of combustion control, electrical equipment, air-cooled furnace walls, enclosed-type centrifuge, high-pressure blowoff valves, valves and fittings, high-pressure plug valves; gages, meters and instruments; regulators and miscellaneous specialties; steam-accumulator system.

POWER TRANSMISSION

Lineshaft Erection. Practical Pointers on the Groundwork Necessary before Erecting a Lineshaft, G. Trimm. Indus. Engr., vol. 83, no. 11, Nov. 1925, pp. 519–523 and 554, 8 figs. Points out methods of rigidly supporting lineshafts so that they will maintain proper alignment in various types of buildings.

PRESSES

Pneumatic Die Cushions. Pneumatic Die Cushions. Machy. (Lond.), vol. 27, no. 681, Oct. 15, 1925, pp. 80–82, 5 figs. Interesting development in sheet-metal drawing and forming.

PULVERIZED COAL

Combustion. Chemistry of Combustion of Pulverized Coal, S. C. Martin. Power Plant Eng., vol. 29, no. 21, Nov. 1, 1925, pp. 1091–1092, 2 figs. High velocity of both air and fuel necessary in removing inert gaseous envelope surrounding particles of fuel.

Pulverizers. The Development of a Unit Pulverizer, R. S. Riley. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 1047–1052, 10 figs. Describes machine for preparing coal to be burned in powdered form and of its development; results of tests to determine its reliability, ability to pulverize wet coal, power consumption, durability, fineness of grinding, etc.

Malleable Furnaces. Malleable Furnace Fired with Pulverized Coal, W. Hathaway. Foundry, vol. 53, no. 20, Oct. 15, 1925, pp. 824–828 and 832, 5 figs. Economy in operation secured through replacement of hand-fired method with new system.

PUMPING STATIONS

Diesel Engines in. Diesel Engine Experience in a Pumping Plant, L. C. L. Smith. New England Water Wks. Assn.—Jl., vol. 39, no. 2, June 1925, pp. 135–137. Describes large economy and satisfactory service on ten months initial run at Huntington, Long Island.

Hydropneumatic. Some Novel Hydro-Pneumatic Pumping Plants. Engineer, vol. 140, no. 3642, Oct. 16, 1925, pp. 413–414, 6 figs. Describes various developments arising from water-lifting device called hydrautomat, which is a self-acting device for using energy of low heads of running water to raise liquids to high levels through agency of compressed air.

PUMPS

Circulating, Motor-Driven. Control for Dual-Driven Circulating Pumps, J. W. Anderson. Elec. World, vol. 86, no. 20, Nov. 14, 1925, pp. 1006–1007, 1 fig. Philadelphia Electric Co. uses synchronous motors in its Delaware station for circulating pumps; describes detailed control system.

PUMPS, CENTRIFUGAL

Starting without Priming. Starting Centrifugal Pumps without Priming, C. H. S. Tupholme. Power Plant Eng., vol. 29, no. 18, Sept. 15, 1925, pp. 946–947, 2 figs. Device, installed at one of big London plants, consists of closed steel plate cylinder located on suction line of pump and somewhat higher level; inlet to device is at top and outlet to pump immediately beneath, conical pipe being fixed between the two; describes action of device.

R

RAILWAY ELECTRIFICATION

Great Northern, Washington. Great Northern Electrification, E. Marshall. Ry. Age, vol. 79, no. 20, Nov. 14, 1925, pp. 899–901, 3 figs. Motor-generator locomotives will be used on 24-mi. heavy-grade section including Cascade tunnel.

RAILWAY MANAGEMENT

Materials Inspection. The Inspection of Railway Materials. Ry. Engr., vol. 46, no. 549, Oct. 1925, p. 353. Writer urges need for improving inspection arrangements in order to secure more effective supervision and economy in time.

RAILWAY MOTOR CARS

Gasoline-Electric. Double End Controlled Brill Gas-Electric Car. Ry. Age, vol. 79, no. 17, Oct. 24, 1925, pp. 757–758, 5 figs. Driven by Brill-Westinghouse 250-hp. gas engine; flexible control incorporated in one throttle.

Oil-Electric. New C. N. R. Oil-Electric Passenger Cars. Can. Engr., vol. 49, no. 19, Nov. 10, 1925, pp. 529–533, 5 figs. Canadian Nat. Rys. introduce two new types of self-propelled car for passenger service; power plant in both cases consists of Diesel engine direct connected to d.c. generators; standard railway-type motors mounted on trucks.

RAILWAY OPERATION

Stopping and Starting Trains, Cost of. Estimated Cost of Stopping and Starting Trains, O. O. Carr. Ry. & Locomotive Eng., vol. 38, no. 10, Oct. 1925, pp. 291–292. Results of series of tests and checks made with dynamometer car in connection with other tests being made at time.

Train Control. Reading Three-Speed Control. A. H. Yocum. Ry. Signaling, vol. 18, no. 11, Nov. 1925, pp. 409–412, 7 figs. Continuous system installed on high-speed dense traffic line of double track, Camden, N. J., to Atlantic City.

RAILWAY REPAIR SHOPS

St. Albans, Vermont. Maintenance of Rolling Stock on New England Railroads, E. Sheldon. Am. Mach., vol. 63, no. 20, Nov. 12, 1925, pp. 769–772, 10 figs. Railway shop of Northern Vermont; making hub liners of boiler plate; driving-box facings are made of fiber board.

RAILWAY SHOPS

Locomotive. Some Impressions of Burnham Locomotive Shop. Ry. Mech. Engr., vol. 99, no. 11, Nov. 1925, pp. 713–718, 11 figs. Improved morale evident at new Denver & Rio Grande Western shop; effective routing and material-delivery systems; time-saving shop devices.

Works Organization System in the Main Locomotive Shops of the Paris-Orleans Railway, M. Bloch. Ry. Engr., vol. 46, nos. 548 and 549, Sept. and Oct. 1925, pp. 302–309 and 337–344, 24 figs. partly on supp. plate. Details of system which has successfully solved many problems and resulted in effecting considerable economies in time and labor.

RAILWAY SIGNALING

Automatic Block. I. C. C. Signal Statistics. Ry. Signaling, vol. 18, no. 11, Nov. 1925, pp. 429–433, 3 figs. Review of block-signals statistics issued by Bur. of Safety of Interstate Commerce Commission from information furnished by railroads; automatic block mileage increased 2302 miles in 1924.

Colored-Light Signals. Light Signals Replacing Semaphores. Ry. Signaling, vol. 18, no. 11, Nov. 1925, pp. 413–415, 12 figs. New York Central makes this change between Buffalo, N. Y., and Cleveland, O.

Economic Operation. The Economic Aspect of Signaling, A. E. Tattersall. Ry. Gaz., vol. 43, no. 16, Oct. 16, 1925, pp. 454–456, 4 figs. How signaling may be arranged to reduce operating expenses; track circuiting and power signaling; triangular junctions.

Maintenance of. Maintenance of C. & N. W. Terminals. Ry. Signaling, vol. 18, no. 10, Oct. 1925, pp. 367–374, 19 figs. Heavy passenger traffic requires efficient organization on 19 interlocking and intervening automatic signals.

Track Circuiting. Direct-Current Track Circuits and the Transient Track, A. E. Tattersall. Ry. Engr., vol. 46, no. 549, Oct. 1925, pp. 360–362 and 368, 5 figs. Analysis of question of switching resistance.

Improving Direct Current Track Circuits, J. B. Weigel. Ry. Signaling, vol. 18, no. 11, Nov. 1925, pp. 421–423, 5 figs. Broken rail protection; average track circuit; track shunts which will drop relay armatures; advantages of reducing energy consumption. (Abstract.) Committee report before Am. Ry. Assn.

RAILWAY TRACK

Grade Crossings. Highway Crossing Protection, A. H. Rudd. Ry. Signaling, vol. 18, no. 11, Nov. 1925, pp. 417–420. Advantages of center of road location for signal; disadvantages of center mounting; advantages and disadvantages of roadside location; summary of points to be considered; uniformity of indication and signals needed; study of results of crossing accidents. (Abstract.) Committee report before Am. Ry. Assn.

RAPID TRANSIT

Multiple-Unit Train Control. Multiple-Unit Train Control (Vielfachsteuerung der Wiener elektrischen Stadtbahn), L. Mandich; and Multiple-Unit System of the Vienna Rapid Transit (Einiges über das Vielfachsteuerungssystem der Wiener Stadtbahnwagen), P. v. Sztrókay. Elektrotechnik u. Maschinenbau, vol. 43, no. 38, Sept. 20, 1925, pp. 756–760, 9 figs.; and 760–766, 13 figs. Describes number of electromechanical construction details of Vienna subway and elevated multiple-unit train control, designed for 6-car or 9-car trains operating with 750-volt direct current; contactors are supplied with 55 volts derived from potentiometer resistance.

REFRACTORIES

Gray-Iron Foundry. Refractory Requirements in the Gray Iron Foundry, R. Moldenke. Am. Ceramic Soc.—Jl., vol. 8, no. 11, Nov. 1925, pp. 712–719. Calls attention to lack of information on foundry refractories on part of both foundrymen and makers of refractory materials; enumerates application of these materials in foundry practice, and details requirements sufficiently to enable manufacturer to select proper grades of brick and clay for cupola and air-furnace operation, as well as for lining up of ladles.

Thermal Efficiency. The Relation of Structure and Composition to Thermal Efficiency of Refractories When Used in Regenerators, S. M. Phelps. Am. Ceramic Soc.—Jl., vol. 8, no. 10, Oct. 1925, pp. 648–654, 5 figs. Study shows relative rates of heat transmission in typical clay, silica, diaspore, fused alumina and silicon carbide refractories, when used as checker brick; it is shown that by lowering porosity of checker brick increase in efficiency is obtained by virtue of its greater heat capacity, which is function of weight and specific heat of material.

S

SAND, MOLDING

Core Sands. Methods of Testing Core Sand Mixtures, J. F. Harper and W. J. Stevenson. Am. Foundrymen's Assn.—advance paper, no. 496, for mtg. Oct. 5–9, 1925, 12 pp., 2 figs. It would appear that green or unbaked strength of core sands should be determined by means of Doty cohesiveness test and baked strength by means of transverse test as outlined; transverse test has proved excellent method of comparison and it lends itself to easy operation without large number of testing variables.

Selection and Blending of Core Sands, A. A. Grubb. Am. Foundrymen's Assn.—advance paper, no. 494, for mtg. Oct. 5–9, 1925, 8 pp., 1 fig. Proper working properties of core sands and cores can be readily obtained by proper blending of sharp sand and bonding sand; two general types of core sand are distinguished by their (colloidal) clay content; those sands which are low in clay cannot be easily over-rammed, are more economical of binder and produce cores which are more readily removed from castings; those which are higher in clay content are less fragile while green and more open in proportion to their green bond. See also (abstract) in Can. Foundryman, vol. 16, no. 10, Oct. 1925, pp. 21–22.

Handling. Reducing Sand Handling Costs. Iron Age, vol. 116, no. 22, Nov. 26, 1925, pp. 1437–1439, 5 figs. Conveyors for unloading incoming cars and elevators and dump trucks for removing sand from storage to mixer eliminate labor at No. 1 foundry of Allis-Chalmers Mfg. Co., West Allis, Wis.

Life of. The Life of Molding Sands, C. M. Nevin. Am. Foundrymen's Assn.—advance paper, no. 465, for mtg. Oct. 5–9, 1925, 30 pp. Deals with series of investigations made with view to determine factors affecting durability of molding sand; discusses all factors which affect life of sand, which are listed as quality and amount of bond, rehydratability, oxidizing and reducing conditions, fusion point, size of casting, pouring temperature, permeability to gases, tempering water, and character of metal; details of various series of tests; methods of determining life of sand were worked out and checked against each other; discusses short-cut method which may possibly be developed; conclusions.

Mixtures, Control Tests of. Control Tests of Steel Molding and Core Sand Mixtures. Research Group News, vol. 2, no. 3, Oct. 1925, pp. 4–7, 3 figs. Review of activities of Joint Committee on Molding Sand Research, undertaken by Am. Foundrymen's Assn. in coöperation with other organizations; describes routine methods which have been very beneficial in maintaining uniformity in molding and core-sand mixtures.

Treating and Handling. A Method of Treating and Handling of Molding Sand, M. Sklovsky. Am. Foundrymen's Assn.—advance paper, no. 482, for mtg. Oct. 5–9, 1925, 12 pp., 8 figs. Describes method and special apparatus in handling molding sand in continuous-operation unit; molding sand is not hand shoveled at any stage of production operation; special revolving shelved apparatus is used to cool, aerate and cut sand so that sand passes through complete cycle every 30 minutes; number of filled molds at any time is less than 5 per cent of total daily production; this rapid cycle permits use of very few flasks and facilitates quick change over jobs. See (abstract) in Foundry, vol. 53, no. 21, Nov. 1, 1925, pp. 882–885, 8 figs.

SCREW MACHINES

Five-Spindle. New Five-Spindle Screw Machine Speeds Drilling Operations. Automotive Industries, vol. 53, no. 18, Oct. 29, 1925, pp. 746–747, 2 figs. Non-stop, semi-automatic machine does not have to be stopped for insertion of work; parts placed in jig clamped automatically; completed work is ejected.

SEAPLANES

Gloster-Napier III. The Builders of the Gloster-Napier III. Aviation, vol. 19, no. 17, Oct. 26, 1925, p. 583. Details of Schneider Trophy entry by designer of British standard pursuit plane.

Racers. The Schneider Cup Seaplane Race. Aviation, vol. 19, no. 16, Oct. 19, 1925, pp. 547–549, 7 figs. Types of machines to compete in race at Bay Shore Park, Md., Oct. 24, 1925.

Supermarine-Napier S. 4. The Schneider Cup Seaplane Race. Flight, vol. 17, no. 39, Sept. 24, 1925, pp. 609–614, 10 figs. History of Schneider Cup Race; describes British machines which are to take part, Subermarine-Napier S.4, and Gloster-Napier III. See also Aeroplane, vol. 29, no. 13, Sept. 23, 1925, 9 pp. between pp. 357 and 372, 13 figs.

SEMI-STEEL

Mixing. Semi-Steel, J. H. List. Foundry Trade Jl., vol. 32, no. 479, Oct. 22, 1925, p. 343. Describes method of mixing with which author has had several years of experience.

SHAPERS

Crank, Speeds of. Crank-shaping Machine Speeds, K. Massa. Machy. (Lond.), vol. 27, no. 681, Oct. 15, 1925, pp. 70–71, 2 figs. Author describes quick and easy alternative to arduous graphical methods of solving link mechanisms, and one which is much more precise than usual diagram.

SHEET METAL

Drawability of Sheets and Strips. Drawability of Sheets and Strips, H. S. Marsh and R. S. Cochran. Iron Age, vol. 116, no. 19, Nov. 5, 1925, pp. 1251–1252, 1 fig. Marco system of measuring; simplified method of expressing Erichsen and similar results.

SHEET-METAL WORKING

Hot Stampings. Hot Stampings and Their Production, G. F. Keyes. Soc. Automotive Engrs.—Jl., vol. 17, no. 5, Nov. 1925, pp. 452–454, 5 figs. Dies are cast from models; make "pick-ups" for "break-downs;" quality results from long experience.

SLIDE RULES

Making of Special. The Making of Special Slide Rules, G. W. Greenwood. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 1002–1006, 14 figs. Details of steps to be taken in constructing arithmetical and logarithmic scales, and of their use in construction of slide rules; description of slide rules for solution of various formulas.

SLOTTING MACHINES

Puncher. Large Butler Puncher-slotting Machines. Machy. (Lond.), vol. 27, no. 679, Oct. 1, 1925, pp. 18–19, 2 figs. Machines built by Butler Machine Tool Co., Halifax, and designed specially for cutting teeth of large cast-steel wheels used for mill rolls and billet shears.

SMOKE

Abatement. Smoke Abatement, F. G. McHugh. Domestic Eng. (Lond.), vol. 45, no. 9, Sept. 1925, pp. 189–192. Discusses industrial and domestic smoke; suggested remedies, including electricity, gas, central heating, and smokeless fuel manufactured by low-temperature carbonization.

SOLDERS

Soft, Specifications for. British Specification for Soft Solders (Grades A, B, C, D, E, F, G, H and J). Brit. Eng. Standards Assn., no. 219, June 1925, 4 pp. Specification covering chemical composition, chemical test, and rejection. Table giving analysis of British Standard soft solders.

SPRINGS

Automobile. British Standard Schedule of Steels for Laminated Springs for Automobiles. Brit. Eng. Standards Assn., no. 5010, Mar. 1925, 6 pp. Covers chemical composition, dimensions, concavity, margins of manufacture, heat treatment and mechanical tests; table giving standards sections for steels for laminated springs; appendix giving approximate metric equivalents.

Electric Measuring Instruments. Springs for Electrical Measuring Instruments, B. W. St. Clair. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 1057–1058, 4 figs. Brief statement of general spring problem in so far as it relates to electrical instruments.

Helical. Manufacture of Commercial Steel Helical Springs, F. H. Brown. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 1053–1055, 2 figs. Present status of art of manufacturing small- and medium-diameter springs; trade requirements; methods of manufacture; materials and their selection.

Weighing. Characteristics of Weighing Springs, J. W. Rockefeller, Jr. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, p. 1056. Duties performed by spring of weighing machine; presents table showing increase of deflection under continued stress.

STANDARDS

German N. D. I. Reports. Report of the German Industrial Standards Committee (Normenausschuss der Deutschen Industrie). Maschinenbau, vol. 4, no. 20, Oct. 1, 1925, pp. 1015–1021, 4 figs. Details of proposed standards for picklocks, crude disks, nut safety plates with tongue, mathematical signs, mechanical heat equivalent, turnbuckles, and piston rings.

STEAM

High-Pressure. Electrotechnics and High-Pressure Steam (Elektrotechnik und Hochdruckdampf), Löffler. Elektrotechnik u. Maschinenbau, vol. 43, no. 28, Sept. 20, 1925, pp. 738–744, 4 figs. Discusses production of high-pressure steam, safety of high-pressure vessels, application in electric power plants, bleeding steam for feedwater preheating, pulverized coal firing, etc.; concludes that with high-pressure steam operation greater efficiency can be obtained than with any other method of energy production.

Growth of Steam Pressure and Economies, W. R. Herod. Power Plant Eng., vol. 29, no. 22, Nov. 15, 1925, pp. 1137–1138, 2 figs. Recital of events that have reduced steam consumption from 150,000 to 11,000 B.t.u. per kw-hr. generated.

High-Pressure Steam Testing Laboratory at Bridgeport. Power, vol. 62, no. 21, Nov. 24, 1925, pp. 804–806, 8 figs. 1200-lb. boiler and laboratory now in use for testing safety valves, will be available for high-pressure research and development work; special equipment insures safety, convenience and flexibility.

Natural, from Geyser. Electric Generators Driven by Geyser Power, J. Hammond. Assn. Chinese & Am. Engrs.—Jl., vol. 6, no. 7, July 1925, pp. 73–75. Two wells were drilled in Sonoma County, California; at depth of 203 ft. unharnessing constant flow of live, superheated steam; electrical possibilities were tried out by connecting 35-kw. General Electric turbine-generator to original tap; nearby hotel, cottages, etc., were electrically illuminated from this source.

Pressure Regulation. Pressure Regulation in Process-Heating Installations (La distribution de la vapeur à pression constante). Génie Civil, vol. 87, no. 13, Sept. 26, 1925, pp. 271–273, 7 figs. Live steam has often to be used to supplement steam exhausted or extracted from prime movers, and there are frequently considerable variations in pressure owing to independent fluctuations in demand for power and process steam; as result of such variations in pressure, valves in heating mains are commonly opened too widely; consumption of steam is therefore excessive, and materials may be damaged by overheating; best results are obtained by operating heating mains at constant pressure, and by not subordinating running of prime movers to steam demand of heating apparatus; describes use of Ruths steam accumulator, controlled by Arca pressure regulator.

STEAM ENGINES

Foundations. Fractures in Horizontal Engine Beds, E. Ingham. Power, vol. 62, no. 18, Nov. 3, 1925, pp. 688–689, 2 figs. Principal causes are unsatisfactory design, faulty casting, and yielding of foundations, each of which is discussed.

Lentz Valve Applied to. British Apply Lentz Valve to Bi-Flow Engines, F. Johnstone-Taylor. Power Plant Eng., vol. 29, no. 21, Nov. 1, 1925, p. 1096, 2 figs. Application of Lentz system to large slow-speed engines of mill class; as present arranged, engines built in Great Britain under Paxman Lentz designs employ a side shaft governor of inertia type.

STEAM METERS

Siemens & Halske. Steam Meters. Power Engr. vol. 20, no 235, Oct. 1925, pp. 386–388, 7 figs. Utility of these instruments is displayed by means of several examples, after which principles and construction of Siemens & Halske design are described.

Ship's. Steam Flow Meters Aboard Ship, W. P. Beehler. Am. Soc. Naval Engrs.—Jl., vol. 37, no. 3, Aug. 1925, pp. 532–546, 5 figs. partly on supp. plate. Practical experience with steam flow meters aboard U. S. S. Maryland has shown that existing objections to use of these meters aboard ships may be readily overcome; details of installation on board U. S. S. Maryland; steam flow meter in machinery space, and boiler meter.

STEAM POWER PLANTS

Cost Analysis. Cost Analysis Indicates Way to Economy. Power Plant Eng., vol. 29, no. 18, Sept. 15, 1925, pp. 947–950, 5 figs. Careful analysis of power costs in Cincinnati office building shows advisability of retaining their private plant.

Economical Operation. Results of an Engineering Study of Paper Coating Factory's Power Plant, J. G. Berger. Power, vol. 62, no. 20, Nov. 17, 1925, pp. 752–753, 2 figs. Outline of method followed in study of power problems of factory; engines were overloaded to point of poor economy; purchased current was recommended for auxiliary power, which plan reduced cost of power.

Fuel Waste. An Amazing Example of Fuel Waste F. C. DeWeese. Power Plant Eng., vol. 29, no. 22, Nov. 15, 1925, pp. 1152–1154, 2 figs. Investigation of conditions in individual power plant reveals loss of $17,000 per year.

Glass Factory. National Plate Glass Co. Completes New Power Plant. Power Plant Eng., vol. 29, no. 21, Nov. 1, 1925, pp. 1080–1086, 21 figs. Plant of 10,500-kw. generator capacity is part of new $7,000,000 factory at Ottawa, Ill.; it furnishes all steam, electricity and water for factory; eight 600-hp. boilers installed; coal and ash handling; feedwater supply and method of treating; turbine room and pumping equipment.

Industrial. The Supply of Industrial Power, Wm. H. Larkin, Jr. Mech. Eng., vol. 47, no. 11a, Mid-November 1925, pp. 993–1001, 7 figs. To assist in determining efficiency of plant operation, tables of actual operating data and costs from industrial power plants scattered about country are shown, including plants which use purchased electric power; paragraphs are included on economy of operation which indicate desirability of power-plant supervision from manager's office—need of instruments so that what is taking place can be known; necessity and value of feedwater treatment; importance of accuracy in making up power costs; advisability of coal and fuel testing; outlines methods by which quality and relative cost of supply of industrial power may be estimated.

Public Printer, Washington, D. C. United States Public Printer Makes Large Saving by Rebuilding Power Plant. Power, vol. 62, no. 19, Nov. 10, 1925, pp. 712–714, 1 fig. By dismantling its power plant and converting it into substation, and taking power from Capitol's power plant, U. S. Public Printer, Washington, D. C., has succeeded in making saving of over $37,000 per year for power and steam; if value of condensing water, taken from city's main is included, saving per year amounts to over $60,000; nearly 20,000 sq. ft. of floor space was made available and efficiency of power plant materially increased.

Small. Justifiable Small Power Plants, A. B. Mallison. Instn. Elec. Engrs.—Jl., vol. 63, no. 345, Sept. 1925, pp. 896–901 and (discussion) 901–915. Discusses power plants, water, wind, by-product to process steam, from process refuse, household and town refuse; comments on small self-contained power plant relative to superpower station and its network; examples of capital and operating costs of typical installations in various industries.

STEAM TURBINES

Back-Pressure. Steam-Consumption Tests on a Back-Pressure Turbine Built by Brown, Boveri & Co., Ltd., Baden, Switzerland, A. Stodola. Mech. Eng., vol. 47, no. 11, Nov. 1925, pp. 915–916, 1 fig. Results of tests on 1000-kw. back-pressure turbine fitted with single-row impulse wheel and 28 reaction stages mounted on a drum. Translated from Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 37, Sept. 12, 1925.

Brown-Boveri. The New Brown Boveri Turbines for Large Outputs, W. G. Noack. Brown Boveri Review, vol. 12, no. 10, Oct. 1925, pp. 199–202, 4 figs. Describes new type of turbine for large outputs which is a reaction turbine constructed in three cylinders for normal heat drops; only first and second stages work on impulse principle but with a certain amount of reaction.

Efficiency. Steam Measurements of a BBC Maximum Efficiency Turbine (Dampfmessungen an einer BBC-Grenzleistungsturbine), Ad. Meyer. Elektrotechnik u. Maschinenbau, vol. 43, no. 40, Oct. 4, 1925, pp. 800–805, 9 figs. Details of verification test for determining thermodynamic efficiency at various loads of Kopenhagen turbine, carried out by Prof. Dresden of Delft, showing an efficiency of 80.3–83 per cent at full load, 78.9 per cent at 70 per cent load, and 81.6 per cent at 30 per cent excess load, considered as very good for a turbine of simple design.

Valve Gear for. Valve Gear with Exhaust-Steam Pressure Regulation for Small Steam Turbines (Steuerung mit Abdampfdruck-Regelung für Kleindampfturbinen), Steuer. Zeit. des Vereines deutscher Ingenieure, vol. 69, no. 45, Nov. 7, 1925, p. 1408, 1 fig. Describes gear used by Kuhnert Turbo Works, Meissen, in connecting a turbo-generator to a 3-phase system whose power is greater than that of turbine set in question.

STEEL

Aeronautics, Use in. Steels Used in Aero Work, W. H. Hatfield. Roy. Aeronautical Soc.—Jl., vol. 29, no. 178, Oct. 1925, pp. 469–511 and (discussion) 511–534, 30 figs. Deals with use of steel in aeronautics; discusses use of high-class material; scientific methods in works practice; duties of various parts; factors of strength; mechanical tests; thermal phenomena of steels; typical steels; forging and drop stamping; normalizing and annealing; hardening and tempering; machining properties; case-hardening; specifications.

Alloy. See ALLOY STEELS.

Automotive. Improvements in Automotive Steels, W. G. Hildorf. Iron Age, vol. 116, nos. 21 and 22, Nov. 19 and 26, 1925, pp. 1378–1380 and 1447–1450, 20 figs. Nov. 19: Difficulties due to seams and dirty steel; normal and abnormal steels; effect of heat treatment. Nov. 26: Fracture testing of steel; reedy or woody fractures; impact values and fractures; grain size. (Abridged.) Paper presented to Am. Gear Mfrs. Assn.

Corrosion-Resistant. Modern Developments in Steels Resistant to Corrosion, W. H. Hatfield. Engineering, vol. 120, no. 3125, Nov. 20, 1925, pp. 657–660, 4 figs. Theory of corrosion; influence of modified composition upon resistance to various corroding media; mechanical and other properties of steels as affecting their application. Paper read before Instn. Eng. Inspection.

Defective. Defective Material and Processes, H. Brearley. Forging—Stamping—Heat Treating, vol. 11, no. 10, Oct. 1925, pp. 375–378, 6 figs. Commends use of simple means of investigation for defects such as pickling, etching and sulphur printing.

Definition. Definition of "Steel" and "Cast Iron," K. Honda. Iron & Coal Trades Rev., vol. 111, no. 3003, Sept. 18, 1925, p. 450, 2 figs. Discusses different definitions.

Hammer-Hardening. Hammer-Hardening of Steel (L'écrouissagede l'acier. Etude et applications de deux lois fondamentales), P. Régnauld. Revue de Métallurgie, vol. 22, no. 10, Oct. 1925, pp. 633–649, 4 figs. Discusses elastic limit, tensile strength of hammer hardened steel, coefficient of Poisson, elongation, etc.; concludes that a hammer-hardened piece is in a state of false equilibrium, its elasticity differing with direction, etc.

Iron and. See IRON AND STEEL.

Manganese. See MANGANESE STEEL.

Rolled, Defects in. Developments in Drop Forging Production. Forging—Stamping—Heat Treating, vol. 11, no. 10, Oct. 1925, pp. 353–354. Brief review of most prevalent defects in rolled steel found by regular bar inspection; accurate checks possible on forging qualities of steel.

Stainless. Chromium-Nickel Rustless Steel, W. H. Hatfield. Metallurgist (Supp. to Engineer, vol. 140, no. 3644), Oct. 30, 1925, pp. 151–154, 5 figs. Results of researches undertaken for purpose of learning whether, by materially modifying composition of steel, range of resistance could be considerably extended; investigations included determination of influence of varying contents of chromium, with and without addition of considerable percentages of other alloying elements; describes very remarkable characteristics of steel belonging to quaternary iron-carbon-chromium-nickel system, and gives typical values for this steel as compared with plain chromium rustless steels.

STEEL CASTINGS

Manufacture for Navy Use. Making Miscellaneous Steel Castings for Navy Use, D. F. Ducey. Am. Foundrymen's Assn.—advance paper, no. 475, for mtg. Oct. 5–9, 1925, 13 pp., 4 figs. Methods used in managing steel foundry supplying repair castings for U. S. Navy; describes equipment of foundry; discusses special green sand facing together with use of special fillets; describes system of planning and routing and forms used. See (abstract) in Foundry Trade Jl., vol. 32, no. 478, Oct. 15, 1925, p. 330, 1 fig.

Samples, Preparation for Chemical Analysis. Preparation of Samples from Steel Castings for Chemical Analysis. Research Group News, vol. 2, no. 3, Oct. 1925, pp. 7–8. Enumerates cause from which incorrect determinations may result; emphasizes importance of precautions such as are outlined.